I. C. 6946 JUNE 1937

DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

RECOMMENDATIONS OF THE UNITED STATES BUREAU OF MINES ON CERTAIN QUESTIONS OF SAFETY AS OF OCTOBER 1, 1936

RECEIVED
O. S. U. LIBRARY

BY

MINE SAFETY BOARD

AFTER THIS REPORT HAS SERVED YOUR PURPOSE AND IF YOU HAVE NO FURTHER NEED FOR IT, PLEASE RETURN IT TO THE BUREAU OF MINES, USING THE OFFICIAL MAILING LABEL ON THE INSIDE OF THE BACK COVER.

I. C. 6946
June 1937

INFORMATION CIRCULAR

DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

RECOMMENDATIONS OF THE UNITED STATES BUREAU OF MINES ON CERTAIN QUESTIONS OF SAFETY AS OF OCTOBER 1, 1936[1]

By the Mine Safety Board[2]

CONTENTS

Page

Introduction 3
Organization and scope of Mine Safety Board 3
Increased scope of Mine Safety Board's activities, order of Oct. 1, 1936 3
Definition and application of term "permissible" 5
Decision No.
1 Miners' lamps, kind and use of in coal mines 5
2 Explosives, kind of and method of use in coal mining. 6
3 Defining nongassy, slightly gassy, and gassy coal mines . . . 7
4 Auxiliary fans or blowers in coal mines and coursing of air . 10
5 Prevention of coal-dust explosions by rock dusting 11

---

[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6946."

[2] The following list gives the names of past and present (October 1, 1936) members of the Mine Safety Board concerned in the formulation of one or more Recommendatory Decisions and their periods of service. The dates of approval by the Director of the Bureau of Mines of the decisions indicate which were made during the respective periods:

Present members, date of appointment	Past members, dates of service
George S. Rice, May 20, 1924.	Ozni P. Hood, May 20, 1924, to June 30, 1936.
Daniel Harrington, Aug. 3, 1926.	Royd R. Sayers, May 20, 1924, to Dec. 31, 1932.
Arno C. Fieldner, Jan. 30, 1933.	Thomas T. Read, May 20, 1924, to Mar. 15, 1926.
Charles F. Jackson, July 1, 1935.	Matthew van Siclen, May 20, 1924, to Oct. 31, 1926.
	Charles W. Wright, Mar. 19, 1928, to July 16, 1935.

Original from THE OHIO STATE UNIVERSITY

CONTENTS (Continued)

Page

Decision No. (Continued)

6 Sealing all parts of a mine that cannot be kept well ventilated and inspected 12
7 Coursing "intake" and "return" air currents in separate shafts, slopes, or drifts 13
8 Definitions used in coal-mine ventilation regulations but that may also be applied to ventilation in metal and other mines 14
9 Quantity and quality of air needed in ventilation of coal mines 15
10 Providing ways of escape from a mine or part of a mine . 17
11 Coursing ventilating currents in coal mines with reference to haulage and hoisting 18
12 Methods of firing shots in coal mines 19
13 Electrical equipment that should be used in coal mines which may become gassy 22
14 Clearance spaces for travel in haulageways, shelter holes, and location of trolley and other electrical conductors 24
15 Wetting machine cuttings, the face, and tops of cars to allay coal dust 25
16 Machine cuttings to be removed in coal mining 26
17 Lessening the formation and distribution of coal dust in haulageways of coal mines 26
18 Superintendents and foremen of coal mines should have State certificates of competency 27
19 Internal-combustion engines for mine haulage 28
Diesel mine locomotives 29
20 Ventilation in the development and operation of tunnels, drifts, slopes, and shafts 29
21 Method of setting posts in main haulageways, slopes, and inclined shafts 30
22 Sealing or guarding surface openings of mines 31
23 Checking men into and out of mines 32
24 Guarding trolley and bare power lines 33
25 Barrier pillars between adjacent mines 34
26 Allaying dusts harmful to breathe in the air of mines and tunnels 35
27 Construction of shaft linings as concerns fireproofing and ventilation 37

Index 39

The first 10 recommendatory decisions of the 27 in this paper were given in Information Circular 6091 (December 1928); these and the eleventh decision were included in Information Circular 6139 (May 1929) and, with the twelfth and thirteenth decisions, were included in Information Circular 6198 (November 1929), and, with decisions 14 to 25, were again reported in Information Circular 6732 (July 1933). This paper reports all the decisions,

Original from THE OHIO STATE UNIVERSITY

27 in number, to October 1, 1936. No changes have been made from the original wording of the decisions; a few editorial changes in titles of decisions and in the wording of the footnotes have been made, as well as some alterations and additions to the wording of the explanatory matter following each decision.

INTRODUCTION

Organization and Scope of Mine Safety Board

Mining men and State officials in their efforts to make mining safer are confronted from time to time with various complicated questions. In recent years these questions have tended to increase with the use of mechanical appliances. Twenty-five years ago electricity had been used but little in mines; today there is practically no other means of transmitting power employed in American mines, except that in metal mines compressed air is used, chiefly for drilling and for operating small portable hoists. In coal mines there has been a great increase in mechanization, which tends to concentrate the work of production in small areas and to increase the local difficulties of ventilation; also, it has intensified locally the hazard from coal dust as well as firedamp in bituminous and subbituminous mines.

The answers to the questions that arise are not always obvious, as is shown by the fact that even able, experienced men differ in their opinions of the best way to overcome a particular mining hazard. The difficulty of solving the problems is also demonstrated by the varying provisions in mine-safety rules, both in official regulations and in the rules of those mining companies that are endeavoring to do more than follow the letter of the law. Such differences of opinion as to the best way of meeting a difficult situation are often found within the same mining organization, and, similarly, varying opinions are held by different members of the Bureau of Mines staff.

To reduce differences of opinion and to obtain a generally acceptable decision on any question, a Mine Safety Board was established by the Director of the Bureau of Mines by order dated May 20, 1924 (effective June 1, 1924) -

> ***to consider questions arising within any divisions of the Bureau that require a definition of the Bureau's collective opinion as to safety practices, safety devices, or safety methods for underground operations or open-pit mining. ..... The approve decisions shall form the basis of teaching and policy for the Bureau.

Increased Scope of Mine Safety Board's Activities, Order of October 1, 1936.

The scope of the Board's activities was increased by an order of the Director of the Bureau of Mines, effective October 1, 1936, as follows:

Original from THE OHIO STATE UNIVERSITY

> It shall consider questions referred to it by the Director or branch chiefs that require definition of the Bureau's collective opinion as to safety practices, safety devices, safety methods, and related matters pertaining to health and safety. It shall make formal minutes of its decisions and report them to the Director for approval or disapproval. The approved decisions shall form the basis of teaching and policy for the Bureau.

The decisions so far made for public issuance relate chiefly to questi on which there have been the greatest differences of opinion and to the bes method of meeting certain special or new dangers. Other decisions will be rendered from time to time. Recommendations of Bureau engineers have alrea been issued on many general mine-safety problems, the answers to which are obvious or on which there is practical agreement among mine-safety men. These recommendations are contained in various publications of the Bureau; and while these publications have been issued with the Bureau's sanction, the thoughts expressed in many instances are those of the individual author or authors rather than of the Bureau of Mines as an organization.

The wording of the decisions makes their application largely self-evident, but a certain amount of additional explanation is given as to the detailed purposes and reasons for which they have been formulated. All the points of practice covered by the decisions were brought out in a study of reports, made for and by the Bureau, of mine fires, explosions, and general accidents in mines. As previously mentioned, it was found that the different members of the Bureau staff did not always agree as to the best method to recommend for technical handling of a specific complicated problem. Such questions as affect fundamental policies of the Bureau on safety technology are referred to the Mine Safety Board, the members of which attempt to reach a common opinion.

Whenever practicable, a tentative decision that has been reached unanimously by the Mine Safety Board is submitted to members of the Bureau staff at the stations and in the field. Their comments are considered and may lead to changes in the draft. The final draft is submitted to the Director of the Bureau; if the recommendation is approved, it becomes the decision of the Bureau on the specific question involved and is binding on all Bureau personnel.

The 27 decisions formulated up to October 1, 1936, are presented in the order of their approval. The reasons are given for the formulation of each decision, and the application of each when not obvious is explained.

Many of the decisions relate specifically to coal mining because of its numerous and special hazards due to inflammable gas and dust. Others apply especially to metal and other mineral mining, and a few are particularly related to the driving of long tunnels. But so far as practicable, the wording of the decision is general rather than specific and is made applicable to as many kinds of mining as possible.

The order in which the different decisions appear has no significance as to relative importance. The decisions were made as the specific question or questions to which they relate were submitted - generally by field representatives of the Bureau - to the higher officials of the Bureau.

Definition and application of term "permissible"

In the Bureau's efforts to increase safety in mines that require various materials, appliances, and methods of using them, there were devised certain tests and specifications which, if met, entitle the manufacturer to state that such materials and appliances are approved by the U. S. Bureau of Mines and are "permissible" for use in mines under the limitations prescribed in the approval. For machinery, apparatus, devices, etc., this is indicated by an approval plate attached to the article and for explosives may be printed on the wrapper.

Many of the "permissible" articles, such as miners' lamps, rescue apparatus, machinery, and appliances using electric power, and materials, such as "permissible" explosives, are of special use in underground workings having atmospheres that may be explosive by reason of the inadvertent presence of inflammable gas or coal dust.

Additionally, for example, "permissible" explosives must not produce, in the Bureau tests, more than a specified amount of toxic gas per unit of explosive; gas-testing lamps and devices must be accurate within specified limits as well as safe in use in explosive atmospheres; and breathing apparatus and gas masks must assure an atmosphere for the wearer fit to breathe for a specified length of time.

"Permissible" has a recommendatory meaning. The Federal Bureau of Mines has no mandatory powers. The authority, if exercised, to compel the use in underground workings of "permissible" machinery, apparatus, devices, and materials in place of unapproved ones, lies with the officials of the respective States.

Decision 1,[3] miners' lamps, kind and use of in coal mines

The United States Bureau of Mines recommends that:

1. In all coal mines the portable lamps for illumination be permissible, portable, electric mine lamps; and also

2. In places were firedamp or black damp is liable to be encountered, a permissible, magnetically locked, flame safety lamp for gas detection, or equivalent permissible device, be supplied to at least one experienced employee in each such place; and

3. Any employee before being supplied with a permissible flame safety lamp be examined by a competent official of the mine to assure the man's ability to detect gas; and

---

[3] Approved May 8, 1926.

Original from THE OHIO STATE UNIVERSITY

4. All coal mines whether classed as nongassy or gassy in any part, be supplied with magnetically locked, permissible, flame safety lamps, properly maintained and in sufficient number for all inspection purposes.

Open lamps or so-called "flame safety lamps" of nonpermissible types may cause fires or ignite firedamp and coal dust, and manifestly should not be used in coal mines. Miners' electric lamps have been so improved in illumination, convenience, and safety that it is no longer considered a hardship in mining to use a portable "permissible" electric lamp; in fact, it is quite the reverse.

However, since no approved electric lamp shows the presence of methane or indicates oxygen deficiency, at least one experienced employee in every place where such conditions are liable to be found should be provided with a "permisible" flame safety lamp or equivalent "permissible" device to be used for testing.

Although a "permissible" flame safety lamp is safe if properly assembled and used, there is a possibility of its being a source of ignition of firedamp if the lamp is opened in the mine or the glass broken, or if the lamp is struck by a sharp point or is moved so rapidly or in an air current of such velocity as to cause flame to extend through the gauzes. Accordingly, the use of the "permissible" flame safety lamp should be limited to gas testing by competent and experienced employees, who can determine with accuracy and safety the percentage of methane in the air in excess of 1 1/2 or 2 percent. The flame safety lamp also indicates serious deficiency of oxygen in the surrounding atmosphere.

Before a safety lamp is issued by the man in responsible charge of the safety lamps of the mine, it should be tested in firedamp in an efficient testing cabinet to insure proper assembly and freedom from defects; and at a gassy mine a flame safety lamp should be examined again for defects by a responsible topman, who should also examine men for matches and tobacco before they enter.

Underground employees who work or travel in well-ventilated places should be provided with portable "permissible" electric lamps that give excellent steady light; the good illumination these lamps provide, if maintained in proper condition, tends to prevent accidents from falls and other hazards, and the equipment itself is free from the danger of igniting gas and coal dust.

Decision 2,[4] explosives, kind of and method of use in coal mining

In the interest of safety the United States Bureau of Mines recommends that for blasting in coal mines, permissible explosives, fired electrically, be exclusively used; and that, as an aid to blasting, all coal which is feasible to cut should be cut or sheared.

---

[4] Approved May 8, 1926.

The foregoing decision has reference to the character of the explosives employed for blasting in coal mines. It does not preclude the use of other methods, devices, and appliances for blasting in coal mines (see decision 12, p.19), which have been approved by the Bureau of Mines and placed on its "permissible" lists. One of the conditions of "permissibility" of explosives for use in coal mines is that not more than 1 1/2 pounds shall be used in any one shot; another is that it be fired only by the use of electric detonators of standard make and proper strength. Other conditions of "permissibility" are: Proper placing of the drill hole and the use of incombustible stemming material tightly tamped.

Fuse should not be used for blasting in coal mines; it throws off a train of sparks in burning, and, under the schedule of tests for determining the "permissibility" of explosives for use in coal mines, the employment of fuse for firing renders the explosive nonpermissible.

Nonpermissible explosives, such as black blasting powder, including pellet powder, dynamite, and special explosives that will not pass the Bureau's tests for "permissibility", readily ignite firedamp and coal dust and have been the cause of hundreds of explosions. Complaint is sometimes made that "permissible" explosives are not efficient because they cannot be used efficiently in "blasting off the solid;" this practice, however, is a highly dangerous one and should not be used.

Where coal is properly undercut, sheared, or overcut blasting can be done efficiently and safely with permissible explosive. The design of coal-cutting machinery has so improved that nearly every condition in mining can be met by selection of a suitable cutter and a suitable mining method. More than three-fourths of the coal produced in the United States now is cut by machines. It is claimed that in some coal beds blasting with "permissible" explosives following cutting makes somewhat more screenings than if black blasting powder is employed; even if the claim should be correct for special conditions the Bureau believes that no coal-mine operator is justified in taking the chances of an explosion disaster by using a nonpermissible explosive.

Decision 3,[5] defining nongassy, slightly gassy, and gassy coal mines

The United States Bureau of Mines believes that all coal mines are potentially gassy; but for purposes of administration in respect to prevention of explosions and fires, the Bureau recommends the following classification:

Class I Coal Mine: A practically nongassy mine in which inflammable gas in excess of 0.05 percent cannot be found by systematic search.

---

[5] Approved May 8, 1926.

Original from THE OHIO STATE UNIVERSITY

Class II Coal Mine: A slightly gassy mine in which -

(1) Inflammable gas has been found[a] but in amount less than 2 percent in still air in any active or unsealed abandoned workings; or

(2) Inflammable gas can be found, but in amount less than 4 percent, in some place from which the ventilating current has been shut off for a period of 1 hour; or

(3) Inflammable gas can be found[b] but in amount less than 1/4 percent, in a split[c] of the ventilating current; or

(4) Inflammable gas enters a split[c] of ventilating current at a rate[d] of not more than 25 cubic feet per minute.

Class III Coal Mine: A gassy mine in which inflammable gas is found in amount greater than specified for a class II coal mine.

---

[a] By employing a "permissible" flame safety lamp, with flame drawn low, or by employing a permissible gas detector or indicator, or by sampling and analysis of sample with an approved gas analytical apparatus.

[b] By sampling and analysis or by employing a "permissible" gas detector or indicator.

[c] If but one continuous ventilating current is employed in a mine this shall be considered a "split" for the purpose of this definition.

[d] Determined by sampling, analysis, and ventilating-current measurement.

General Notes Regarding Decision 3

The inflammable gas found in coal mines is, with rare exceptions, metha In coal-mining fields where natural gas is found below the coal measures (i lower geologic horizons) by deep wells that penetrate through or near coal mine workings, there have been instances, fortunately of rare occurrence, o leakage from the well into the mine, which have led to explosions in the mine.[6] Natural gas is chiefly methane - almost always more than 85 percent methane - but it usually contains ethane, propane, and traces of butane; therefore, if the latter components are found with methane in mine air, it is an indication of leakage. The lower limit of explosibility of methane-ai mixture when there is turbulance is 5 percent and of natural-gas-air mixtures with about 10 percent ethane and associated hydrocarbon gases is 4.6 percent. The limit therefore varies with the character of mixture.

---

[6] Rice, G. S., Hood, O. P., and others, Oil and Gas Wells through Workable Coal Beds; Papers and Discussions: Bull. 65, Bureau of Mines, 1913, 101 pp.

To determine, under the foregoing specifications, the classification of a specific coal mine in respect to gas, it is advisable that systematic testing and sampling of the mine air in each split of the ventilating current be done at least three times in a period of not less than 72 hours. All tests and samples of the mine air, except one, should show an inflammable-gas content less than the maximum limit of the class to which the mine will be assigned. In other words, a tolerance of one test or analysis may be permitted to provide for a mistake or a very exceptional occurrence.

When a new mine is being opened in a coal field where existing mines are generally gassy, it is advisable to assume that similar conditions will be found in the new mine; the development and equipment of the mines should be based upon the expectation that it will be assigned to class III.

There is no more disputed question than that covered by this decision as to what constitutes a gassy (or gaseous[7]) mine. Only a few State regulations give any specific directions for determination of gassiness other than that of whether or not approved flame safety lamps are required.

A coal mine is popularly designated a "closed-light" or an "open-light" mine.

Repeated instances of explosion disasters caused by gas ignition in "open-light mines" have shown that the term is misleading and dangerous in its implication. Moreover, such a method of rating a mine as gassy is not satisfactory, partly because there is such a great difference in other requirements - in ventilation, in use of electricity, etc. Also it tends to prevent the adoption of the "closed lamp" by many mine operators who do not like to admit that their respective mines are gassy; although this is not a good reason why the operator should not take maximum precautions, it is a practical consideration. The Bureau's plan in this decision would avoid indefiniteness and confusion by specifying in precise terms what it designates as a "nongassy," a "slightly gassy," and a "gassy" mine. The Bureau's specifications are founded on a study of thousands of analyses of samples of mine air submitted to the Bureau of Mines laboratory at Pittsburgh.

Although this decision specifically refers to defining the gassy or nongassy condition of a coal mine, its provisions should also be applied to those metal mines and tunnels that encounter inflammable gas. Although such occurrences are relatively rare, serious explosions of gas have occurred in water-supply tunnels driven through shales, as at Cleveland, Ohio, and Milwaukee, Wis., and several disastrous explosions have occurred in tunneling in

---

[7] Although the word "gaseous" has been generally used in the United States, "gassy" is considered by the Bureau as more accurate in meaning and is beginning to be more widely used. Literally a "gaseous mine" would be one in which solid matter is not excavated; whereas a "gassy mine" is one in which the presence of gas is incidental to the mining operation.

Digitized by Google Original from THE OHIO STATE UNIVERSITY

California. Gas explosions have also occurred in sinking shafts for salt in New York and Michigan and for potash in New Mexico, as well as in operation of other noncoal mines in several States.

Decision 4[8] auxiliary fans or blowers in coal mines and coursing of air

> In the interest of safety, the United States Bureau of Mines recommends that auxiliary fans or blowers should not be used in coal mines as a substitute for methods of regular and continuous coursing of the air to every face of the mine.

The reason for this decision is the increasing use of auxiliary blowers, which in the United States are nearly always electrically driven, as a substitute for proper coursing of the air. Proper coursing should be obtained by laying out the mine with double or multiple parallel entries, slopes, or rooms, using regularly spaced cut-throughs or crosscuts to provide successive new air connections close to the faces being driven and then successively closing them by stoppings or doors in such manner as to leave only the inner cut-through or crosscut open for air circulation; also suitable splitting of the main air currents is essential to proper coursing in practically all mines (see decisions 3 and 9). In gassy mines, line brattices should be used in each entry, slope, or room, from the last open crosscut to the respective face. There is great danger in the use of auxiliary fans that firedamp will be accumulated by recirculation of the air and will be ignited by an electrical spark. Further, the auxiliary fan as commonly used is intermittently operated - that is, operated only when men are in the heading or room - and bodies of firedamp may collect during times when the auxiliary fan is stopped.[9] Use of electrically driven auxiliary blowers has resulted in a considerable number of explosion disasters.

The term "auxiliary fan" does not apply to a "booster fan." As here used the term "auxiliary fan" applies to a temporary installation that takes only part of the air-current circuit[10] as distinct from a "booster fan," hich is a more permanent installation through which is passed the whole particu-ar circuit of air to increase its pressure (negative or positive) so as to over-ome resistance, with the object of increasing the volume, and (or) forcing the ir in adequate amount through distant workings.

---

[8] Approved Jan. 17, 1927.

[9] The only justification for the use of an auxiliary fan in a properly ventilated coal mine is for emergency work, as in driving a crossheading in rock to make a connection with distant workings, and where it is too far to carry the air properly by a line brattice. In such use the auxiliary fan should be operated continuously 24 hours in the day, the fan and pipe frequently inspected, and the air in the face of the heading tested. It is safer that the fan be driven by compressed air, but if it is electrically driven the motor and switches should be of explosion proof type and an armored power conductor employed; especial attention should be given to thorough insulation of the wiring; and the vicinity further should be fireproofed to prevent the possibility of starting a mine fire from electrical breakdown or overheating of bearings.

[10] Greenwald, H. P., and Howarth, H. C., Recirculation of Air and Mine Gas Caused by Auxiliary Fans used in Coal Mines: Trans. Am. Inst. Min. and Met. Eng., vol. 76, 1928, pp. 164-183. Issued also as Tech. Pub. 110.

The use of a "booster fan" is rarely justified. In most installations in-estigated there was recirculation of the air, and where this happens if methane s given off in the circuit there is a corresponding increase in gas content in he air circulated. Explosions have resulted therefrom. The best way, which is rdinarily sufficient, is to improve airways and (or) to install a more powerful urface fan to obtain adequate pressure and volume of circuits of air throughout he mine. A booster fan installation should be contemplated for ventilating a listant extension of a mine only where it is not practicable to put down a new shaft and when, after all has been done that is possible to improve the airways, he air pressure required would be so high (exceeding 5 inches water gage) as to revent proper operation of the underground ventilating doors.

Decision 5,[11] prevention of coal-dust explosions by rock dusting

> To prevent the propagation of mine explosions, the United States Bureau of Mines recommends rock dusting all coal mines, except anthracite mines, in every part, whether in damp or dry condition. It also recommends that rock-dust barriers be used to sectionalize the mine as additional defense; but these should not be regarded as a substitute for generalized rock dusting.

> NOTE: For detailed specifications as to the kind of rock dust, amount to use, where to be applied and method of sampling and testing, see Bureau of Mines Report of Investigations 2606 and American Engineering Standards Committee "Recommended American Practice for Rock Dusting Coal Mines" quoted in Bureau of Mines Information Circular 6030.

The rock-dusting method[12] of preventing explosions of bituminous-mine dust (anthracite dust was found not to propagate an explosion) has now been accepted by the chief coal-mining countries of the world. It was recommended after exhaustive testing in the Bureau of Mines experimental mine in 1913. The method was officially approved by France about 1917. It was officially required by Great Britain in 1921, and in Germany in 1926.

The term "rock-dust barrier," referred to in the above decision, is used to designate an arrangement in a coal-mine passageway for holding a specific mass of rock dust (the amount varying with the surrounding conditions at the location) either in a single container or a group of containers at or near the top of the passageway, which, on discharge, will extinguish the flame of a coal-dust explosion that may arrive from either direction along that passageway. Many of the types of barriers that have been installed in mines have not been successful in tests in the Experimental mine.

---

[11] Approved Apr. 7, 1927.

[12] The use of incombustible dust to neutralize the coal dust was proposed by William Garforth in 1891, and testing was begun under his direction in 1908 at the Altofts Colliery, Yorkshire, England. In the United States, testing was begun under the Technologic Branch of the U. S. Geological Survey (later the Bureau of Mines) by G. S. Rice and associates in 1909; U. S. Geological Survey Bull. 425, 1910, reprinted as U. S. Bureau of Mines Bull. 20, 1911.

A series of tests of various types of barriers[13] was conducted in the Exp mental mine from 1927 to 1931; and, as a result, 13 barriers of specific desig and dimensions are recommended for certain locations and conditions.

The use of generalized rock dusting in American mines has grown extensively since 1925 and has resulted in greatly lessening coal-dust explosions and loss of life therefrom; but it must be maintained vigilantly or coal-dust explosion disasters will occur. One of the problems that has arisen is how to rock dust in trackless passageways used as airways or escapeways. This has been done by mea of high-pressure rock-dusting machines that blow the dust through large-diameter flexible hose extending through a crosscut from the rock-dusting machine, which i placed on a parallel haulageway. If there is a stopping in the crosscut, a pipe with a valve can be put through it, to which hose connection can be made to the rock-dusting machine, and on the other side by a length of hose extending into t trackless entry. Under some conditions it may be necessary to have men carry th rock dust into the trackless passages in bags or buckets and distribute it by ha

If decision 6 (p. 12) is followed, which recommends sealing all parts of a coal mine that cannot be well ventilated and inspected, there will be a minimum quantity of coal dust to combat in trackless passageways. In intake entries outby the working places practically no float coal dust will be deposited; and in return-air entries, provided watering is done in the face workings as specified in decision 15 (p. 25), only small amounts are likely to be deposited in trackless entries at distances of more than a few hundred feet outby the working places. Therefore, if accumulations of coal dust are cleaned up in trackless entries at the time the track is removed, thereafter it will require relatively small amount of rock dust to combat later deposited float dust; this can easily be distributed by hand.

Decision 6,[14] sealing all parts of a mine that cannot be kept well ventilated and inspected

> In the interest of safety, the United States Bureau of Mines recommends that in coal mines all entries, rooms, panels, or sections that cannot be kept well-ventilated throughout or cannot be inspected regularly and thoroughly, or that are not being used for coursing the air, travel, haulage, or the extraction of coal, be sealed by strong fireproof stoppings.

In the past the question of advisability, from a safety standpoint, of sealing abandoned or unused places in coal mines has been much disputed among mining men. Some have considered that it was highly dangerous to enclose areas in a mine that might fill with a body of gas. The Bureau agrees with this point of view, unless the stoppings are strong and fireproof; and by strong is meant sufficient strength to maintain the stoppings in place if there should be a heavy fall of roof in an empty or partly empty goaf, momentarily compressing the gas or a gas-air mixture in the enclosed area sufficiently to blow out a stopping.

On the other hand, the engineers of the Bureau find from extensive experience that in large room-and-pillar mines in which the pillars are either not extracted at all or not extracted for a long period, the old areas generally are not well-ntilated and often cannot be properly inspected or ventilated because of piles fallen roof and dangers of further falls. Furthermore, these regions act as aces for accumulating dangerous dust as well as firedamp in caved places.

---

[13] Rice, G. S., Greenwald, H. P., Howarth, H. C., Tests of Rock-Dust Barriers in the Experimental Mine. Bull. 353, Bureau of Mines, 1932, 81 pp.

[14] Approved Apr. 26, 1927.

The Bureau believes that the ideal system of room-and-pillar coal mining is take out only a small percentage of coal on the advance, less than 20 percent, d then to extract the pillars promptly on a systematic line of retreat for the ole mine or for a large panel, which may be considered equivalent to longwall treating. By using such methods there are no extensive areas that cannot be ntilated properly, and there is less danger of spontaneous fires.

Where the workings of either a metal or coal mine have been connected to an ljacent mine, and after more or less extraction of the mineral in that part of ne mine the connecting workings are not tightly closed, strong fireproof doors stoppings should be erected in such connections at or near the boundary of the ine. The objective of this is to prevent fire or gases from passing from one mine the other. In the case of coal-mine workings that have been connected, these toppings should not only be fireproof but should be strong enough to resist the ressure of a gas or coal-dust explosion. Explosion tests by the Bureau of Mines n the strength of stoppings[15] indicate that a plain concrete slab of sufficient hickness to act as a flat arch when properly keyed into the ribs and floor probbly is the most practicable form of construction for a fireproof stopping strong nough to resist an explosion of ordinary degree of violence.

In abandoned dipping mine workings that may fill with water, barrier-pillar toppings should be erected to protect lower workings. These stoppings may be ubjected to a dangerously high water pressure, and to protect against this it s necessary to place a pipe fitted with an automatic water release valve through ne or more stoppings. The outlet of the release valve may be connected to the rainage system of the mine. If the water carries entrained gas in dangerous mounts, a suitable device with pipe connection into a return airway should be rovided to release the entrained gases.

In abandoned flat workings, where gas under high pressure may be evolved, a ipe provided with a manually operated valve and a pressure gage should be placed hrough the stopping near the roof for drawing off the gas if the gage indicates hat the pressure is rising too high. If the stopping is not adjacent to a return irway, a release pipe should be laid into the nearest return airway. The manually operated valves on the stoppings pipes for release of gas should be locked and pened for reduction of pressure only by an authorized inspector when the men are ut of the mine. Alternatively, the gas may be released from within the enclosed rea, as is sometimes done, through a hole drilled from the surface, with an automatic relief valve at the top of the casing of the hole releasing the gas at low ressure but preventing air from entering.

Decision 7,[16] coursing "intake" and "return" air currents in separate shafts, slopes, or drifts

In the interest of safety, the United States Bureau of Mines, recommends:

1. That the main intake and main return air currents in mines be in separate shafts, slopes, or drifts.

---

[15] Rice, G. S., Greenwald, H. P., and Avins, S., Concrete Stoppings in Coal Mines for Resisting Explosions: Bull. 345, Bureau of Mines, 1931, 63 pp.

[16] Approved Nov. 7, 1927.

2. That the main intake shaft lining be of fireproof construction and there be a minimum amount of inflammable material in or adjacent to the shaft.

The recommendations in this decision are applicable to any kind of undergro mining. Bureau of Mines engineers engaged in mine-recovery operations during or following fires in coal and metal mines have experienced great difficulty in restoring ventilation and coping with hazardous conditions caused by placing the "intake" and "return" currents, separated only by a partition, in the same mine opening. Even if the partition is fireproof and remains essentially intact, the smoke and fumes at the bottom of the shaft or slope will work around into both compartments almost inevitably. Also, entrance at the surface to either compartment may be made impossible by flame or smoke.

If a strong explosion in a coal mine reaches a shaft in which a partition separates the intake and the return currents, the partition, even though made of concrete, is sometimes blown out because of the unbalanced explosion pressures i the separated compartments of the shaft.

Generally the two compartments in the same mine opening have been used because they were convenient and possibly reduced the initial expense of opening th mine; but such considerations should have no place in the development of a mine, the lifetime of which may be many years.

A fireproof lining in the main intake shaft is recommended to provide a saf means of exit in the event of an explosion or fire. In the greatest mine-fire disaster that has occurred in this country, the Cherry (Ill.) mine fire (1909) in which 259 men were killed, the underground fire that ignited the lining of the intake shaft was short-circuited to the return hoisting shaft and thus prevented the escape of most of the miners.

The best practice today is to have at least three shafts or other openings with fireproof lining and to have the main hoisting shaft nearly neutral, with just enough of a fresh-air intake split to keep it properly ventilated.

It is advisable that there be a distance of at least 200 feet, or as much more as required by State regulations, between the intake shaft and the return shaft and that in this space and (or) immediately adjacent to the shafts no structures of combustible material should be built or electrical transformer erected or combustible material stored.

Decision 8,[17] definitions used in coal-mine ventilation regulations but that may also be applied to ventilation in metal and other mines

The United States Bureau of Mines recommends that in mine ventilation the following definitions be used:

1. The term "intake air" and the term "return air" without qualifying adjectives shall be used only to define mechanical movement of the air respectively in an inward or outward direction with reference to the mine as a whole or to any one group of workings.

2. When health and safety are concerned, the term "pure intake air" shall mean -

(a) Air which has not passed through or by any active workings, and (or)

---

[17] Aproved Feb. 6, 1928.

(b) Air which has not passed through or by any inactive workings, unless these are effectively sealed, and

(c) Air which is free from poisonous gas and by analysis contains not less than 20 percent oxygen (dry basis) and not over 0.05 percent of inflammable gas.

In the various State mining codes unquestionably there is much ambiguity a the meaning of different mining terms. Therefore, as a prerequisite to the mulation of revised or new codes, it is advisable to employ specific standar d terms. There is particular need of this, as miners frequently move from es in one State to another as mines close or for personal reasons.

Decision 9,[18] quantity and quality of air needed in ventilation of coal mines

The United States Bureau of Mines recommends in coal-mine ventilation practice the following specifications as to unit quantity and quality of air:

1. The quantity in cubic feet of pure intake air flowing per minute in any ventilating split shall be at least equal to 100 times the number of men in that split.

2. The quantity of air entering each unsealed place shall be at least 200 cubic feet per minute and as much more as may be necessary properly to dilute and carry away inflammable or harmful gases which may be present.

3. The air shall be made to circulate continuously to the face in every unsealed place into which an appreciable amount of methane enters.

4. The air in any unsealed place shall be considered unfit for men if it shall be found to contain less than 19 percent oxygen (dry basis), more than 1 percent carbon dioxide, or a harmful amount of poisonous gas.

5. If the air in any unsealed place, when sampled or tested in any part of that place not nearer than 4 feet from the face and 10 inches from the roof, shall be found to contain -

(a) More than 1 1/2 percent of inflammable gas, the place shall be considered to be in hazardous condition and require improved ventilation, and

(b) If more than 2 1/2 percent of inflammable gas is found, the place shall be considered dangerous, and only men who have been officially designated to improve the ventilation and are properly protected shall remain in or enter said place.

6. If the air in the split which ventilates any group of workings contains more than 1 1/2 percent of inflammable gas, these workings shall be considered to be in a dangerous condition, and only men who have been officially designated to improve the ventilation and are properly protected shall remain in or enter said workings.

---

[18] Approved Feb. 13, 1928.

This decision, while made primarily for coal mining, contains specifications also applicable to other kinds of mining; it recommends provisions for the minimum quantity of pure air to be furnished to each miner and the minimum velocity of the current in each unsealed place in the mine, the maximum allowable percentages of poisonous and inflammable gases, and the amounts of these that are so dangerous as to call for the withdrawal of men from the respective parts of the mine.

The first provision calls for the customary State regulation for a minimum of 100 cu. ft. of air per min. to be furnished to every man, but as measures in each ventilating split instead of, as in common practice, measured at the foot of the intake shaft or mine entrance. It has been found that there is always a leakage or short-circuiting of air at doors and stoppings, and in some mines only a small part of the intake air reaches the working faces.

The second provision in effect calls for a minimum quantity of air current not only in each active working place but also in every unsealed place.

The third provision calls for circulation of air in each place, whether active or inactive, to the face or end to insure against accumulations of gas in any part of an unsealed place.

The fourth provision specifies the requirements of air suitable for breathing.

The fifth provision specifies a hazardous or dangerous percentage of inflammable gas in the air in an unsealed place, also where and how the tests are to be made to determine the volume of a body of an accumulated gas mixture.

The sixth provision specifies the percentage of inflammable gas in a ventilating split that constitutes such a hazard that miners should be withdrawn and kept out of that split until the dangerous conditions have been removed by improved ventilation.

The foregoing provisions for continuous circulation of air to the faces presuppose that mining officals obey the mining regulations of the respective State in which the mine under consideration is situated and in addition that they follow the best practices in coal-mine ventilation such as -

(a) Coursing air by means of double or multiple entries and parallel rooms, also along connected faces and break lines (see also p.10.)
(b) Employing crosscuts between the double or multiple entries at specified intervals.
(c) Erecting stoppings or doors in every crosscut except the one nearest the head of the respective entries or rooms.
(d) Employing the best type of stopping, which according to the better State regulations, must be built of incombustible material in crosscuts of the main or more permanent openings.

The character of stoppings other than in the main-entry crosscuts is not usually specified in the State regulations, but it is good practice to use incombustible material - preferably massive concrete - for all main stoppings. In room crosscuts, gob walls or dirt filling is usually sufficient if kept tight, or tight board stoppings, preferably gunited or plastered, may be used; but curtains should not be used except in connection with line brattices extending beyond the last open crosscut, because of safety and efficiency. Check curtains in the mouth of a group of rooms to prevent short-circuiting of the air current is proper practice, but the curtains should be kept in good repair. Curtains and line brattices should be chemically treated to render them fire-resisting.

The character of the doors used for directing the ventilating current and eir operation are specified in some of the better State regulations, but the cessity of having doors in duplicate or triplicate between the main intake and turn of the whole current or main splits is not specified, although this is in cordance with the best practice. The Pennsylvania mining law requires that where ere is a door on "any incline plane or road whereon haulage is done by machinery" extra door shall be provided for use in case of necessity; also, wherever a incipal door is placed, an extra door shall be provided to be used in case of cessity. (Art. IX, sec. 8, Pennsylvania Bituminous Mining Laws.)

The character of the overcasts is specified in some of the State regulations, t the advisability of employing "overcasts" or "undercasts" in place of doors erever practical to do so is not emphasized as it should be, except in the case Pennsylvania State mining laws applying to certain conditions, as follows: "In ery slope with workings on both sides, an overcast and an undercast *** shall be rovided as a passageway for the use of employees to cross from one side to the her" (Art. VI, sec. 5); and in gassy mines, "the return air from each split where om 70 to 90 persons are employed shall be conducted by an overcast into the return irway, which shall lead to the main outlet" (Art. IX, sec. 1); also, "in every mine ll new air bridges, overcasts, or undercasts shall be substantially built of masony, concrete, or other incombustible material of ample strength, or shall be driven rough the solid strata" (Art. IX, sec. 7).

In gassy mines, line brattices should be used in headings and rooms to carry e ventilating current close up to the face.

Ventilation regulators are necessary to proper apportionment of the ventilaing current in the different splits. Theoretically, if the splits are laid out o that the resistance to the movement of the air in each is identical, there would e no need of regulators, which cause a loss of power; but while their employment ould be minimized by changes from time to time in the splitting of the air curent, the irregular advance of workings in a mine of large production capacity ecessitates some extent of use.

The number of men on any one split of air is specified in most State regulaions; this number ranges from 45 to 100 persons permitted to work in one continuus air current or split. With adequate ventilation as specified in this decision, ased on the number of men and the inflammable gas content, 75 appears to be a conervative figure to adopt (where not in conflict with State regulations) for the umber of men employed on one continuous air current.

Decision 10,[19] providing ways of escape from a mine or part of a mine

The United States Bureau of Mines, in the interest of safety in all underground mines, recommends that

1. Every underground mine shall have two or more ways of escape to the surface, so arranged and equipped that men can escape quickly.

2. Such ways of escape shall be so separated by at least 50 feet of natural ground throughout their length that damage to one from any source shall not thereby lessen the effectiveness of the other as a means of escape.

---

[19] Approved Aug. 19, 1928.

3. (a) Where the way of escape is a shaft which is steeper than 45° from the horizontal, it shall have incombustible walls or lining and contain no fire hazard from the surface to the lowest level.

(b) Where the way of escape is a drift or slope which is inclined less than 45° from the horizontal, the incombustible walls, or lining, and freedom from fire hazard shall extend at least 200 feet from the entrance.

4. Where but one way of escape has incombustible walls or lining, it shall be the normal intake airway.

5. Not more than 10 men shall be employed in any part of a mine on any one shift until a second way of escape from that part has been provided.

Decision 10 is intended to apply to any kind of underground mine.

The first provision is one that is to be found in virtually all State mining codes. Since the establishment of the Federal Government mine-safety work in 1 there have been numerous accidents in places from which men were unable to escape because there were not adequate arrangements for their getting out quickly, as by hoist in a shaft over 300 feet in depth, or because escape passages were not well timbered, free of debris, and ventilated by intake air currents. For recommendations regarding main intake and return air currents to be in separate shafts, slopes, or drifts and the main intake shaft lining to be of fireproof construction see decision 7. Passages leading to escapeways should be adequately supplied with direction signs.

The second provision is to establish a minimum distance between ways of escape to insure that a fire or explosion that blocks one way would not, at the same time, make the other means of escape difficult or impossible of access. For recommended minimum distance between main intake and return shafts see decision 7.

The third provision relates to making fireproof the shaft, drift, or slope used as an escapeway, the obvious purpose of which is to prevent the respective linings from getting on fire and cutting off the escape of men in the mine.

The fourth provision is to insure that, where only one oscapeway is fireproofed, it should be used as the intake entrance of the mine. This provision is also covered in a different manner by the second clause in decision 7.

The fifth provision prevents the employing of any considerable group of men in any part of any mine where there are not two ways of escape, and limits the group to 10 men on any one shift exposed to a hazard until a second way shall have been made by sinking shafts or slopes or driving drifts or crosscuts from the surface or from other workings.

Decision 11,[20] coursing ventilating currents in coal mines with reference to haulage and hoisting

In the interest of safety, the United States Bureau of Mines recommends that in coal mines, haulage and (or) hoisting be kept in intake air as far as possible.

The advisability of this recommendatory decision has been indicated by many reports by Bureau of Mines engineers on mine explosion and fire disasters. Since

---

[20] Approved May 1, 1929.

e general introduction of "permissible" miners' lamps and "permissible" explo-
ves in gassy and dusty coal mines, and since, on the other hand, the almost
iversal adoption of electricity in this country for underground machinery and
ulage, the chief cause of explosions in recent years has been electrical.
thane accumulations have been ignited by electric arcs either at or near the
rking faces, in poorly ventilated places, and (or) in return airways, and the
sulting explosions, often small at the origin, have been spread disastrously
coal dust. Although coal dust can be neutralized by rock dust, as specified
decision 5, a small percentage of methane in the air greatly increases the
zard of ignition and propagation by coal dust and may require so large an in-
ease in the amount of rock dust that for high percentages of methane in the
r current of a gassy mine effective rock-dusting may be exceedingly difficult
maintain.

The hazard of ignition of gas or coal dust is greatly lessened if all ma-
inery and equipment employed in coal mines is a "permissible" kind.

Trolley locomotive haulage, which is employed so generally, and nonpermissi
chines and hoists that cause electric sparks should never be used except in a
sitive current of pure intake air.

The fighting of mine fires may be especially difficult and dangerous if the
isting **and haulage** is not done in intake air, and numerous lives have been en-
ngered and many lost through having haulage or hoisting on return air.

Decision 12,[21] methods of firing shots in coal mines

The United States Bureau of Mines, extending Mine Safety Decision 2, recommends that for blasting either coal or rock in coal mines, "permissible"[a] explosives or equivalent permissible device be used exclusively, and in addition recommends that in blasting[b]

1. Each charge shall be in a hole properly drilled and stemmed with incombustible material.

2. Each shot shall be fired separately by a permissible single-shot blasting unit, using an electric detonator or igniting equivalent of a kind specified by the Bureau for the particular "permissible" explosive or permissible blasting device.

3. Before and following each shot in gassy and slightly gassy coal mines, examination for gas shall be made with "permissible" flame safety lamp or permissible equivalent,[c] and -

4. If more than 1 1/2 percent of inflammable gas is found in the quantity and by the method specified in Mine Safety Decision 9,[d] the place shall be considered to be in a hazardous condition, and before another shot is fired the gas shall be reduced by ventilation below the percentage and quantity specified in decision 9.

5. Each shot employing explosives shall be prepared and fired by or under the immediate supervision of a man having a State certificate as a mine examiner, fire boss, or foreman; and, whenever conditions

---

[21] Approved Feb. 8, 1930.

Original from THE OHIO STATE UNIVERSITY

permit, all other men than those authorized to prepare and fire shots shall be out of the mine when shot firing with explosives is being done.

---

a/ Any explosive or device that has successfully passed scheduled tests and is officially approved by the United States Bureau of Mines is termed "permissible."

b/ Exception: This rule would not apply where shot firing is done electrically from the surface when all the men are out of the mine.

c/ Mine Safety Decision 1 relative to "permissible" flame safety lamps or equivalent.

d/ Decision 9, paragraph 5, page15: If the air of any unsealed place when sampled or tested in any part of that place not nearer than 4 feet from the face and 10 inches from the roof shall be found to contain -

(1) More than 1 1/2 percent of inflammable gas, the place shall be considered in a hazardous condition and require improved ventilation and -

(2) If more than 2 1/2 percent of inflammable gas, the place shall be considered dangerous, and only men who have been officially designated to improve the ventilation and are properly protected shall remain in or enter said place.

This decision, as stated in its opening words, supplements Mine Safety Decision 2, (p.6), which primarily recommended the use of "permissible" explosives. Since the time of issuing that decision, a blasting device has been tested by the Bureau of Mines and determined to be suitable for use in gassy and dusty mines and has been termed a "permissible blasting device." This instrument consists of a reusable steel cylindrical shell that is charged with highly compressed or liquefied carbon dioxide and contains a heating element to be ignited by an electric squib within the container. A firing circuit can be established only after inserting a bayonet-locked firing plug in the end of the container. Only a permissible single-shot blasting unit should be used for firing.

Permissible explosives are "permissible" only when used in the manner prescribed in the "Schedule of tests." This decision (12) specifies that permissibility requires the shot holes to be properly located with reference to the "burden" of the blast and that the explosive charge be stemmed with incombustible material. The charge should be fired by electrical detonator, using a "permissible" single-shot blasting unit, one shot at a time, except in firing electrically from the surface when all men are out of the mine, as is the practice in some of the mines of Utah and in certain other districts.

The rapid firing of a series of shots in coal mines by shot firers who may not have charged the shots, who proceed from place to place firing groups of shots, and who do not make any inspections presents a great hazard. When several shots are fired in one place, gas may be liberated and (or) coal dust stirred into the air by the first shots, and a subsequent shot may ignite the dust and (or) gas, as has frequently happened.

Furthermore, if one or more of the shots in a face or pillar are termed "depending shots," it is impossible to foresee how much or how little coal is thrown out by the first blast, leaving too light a burden for the second blast or possibly so heavy a burden that it may cause a blown-out shot. No "permissible" explosive lasting device so far tested and given permissibility is absolutely free under conditions of use from the possibility that its flame will extend outside the t hole; and if there is inflammable gas in explosive proportions in an amount excess of that given in clause 4 of decision 12, or if a dense heavy cloud of l dust is present, ignition may occur, which may lead to a disastrous explosion. hough this combination of circumstances is, perhaps, rare, it has occurred and occur again if every precaution is not taken. This question is fully dis- sed by Harrington and Howell in Bureau of Mines Technical Paper 567.

Special Conditions That May Require Exceptions to Single Shot-Firing

Where more shots than one are to be fired in a working place of a mine, it is sible that under some conditions special hazards may exist in firing shots arately and inspecting between shots; in such cases simultaneous, multiple shot ing may be allowable when permitted by the respective State mining regulations. s condition may occur in steeply pitching workings or in working places where bursts of gas may be released by shot, or where the roof, draw slate, or coal so friable that despite use of usual good timbering methods, falls are likely occur after a shot, making it dangerous to inspect the roof and to connect the ing leads for the next shot. This possible exception making choice of a lesser ard does not mean that the Bureau of Mines recommends simultaneous multiple t firing when it is practicable to make careful inspection for gas and roof ditions before and after each shot.[22] When multiple shot firing is necessi- ed by the conditions, it should be done by firing simultaneously with standard ctric detonators. The use either of fuse or of delay-action detonators some- es termed "delay electric blasting caps" or of "delay electric igniters", is gerous because of the possibility that a delayed shot may ignite gas or a coal- t cloud thrown out by a previous shot.

No multiple shot-firing device for use in gassy coal mines had been approved the Bureau of Mines at the time of completing this paper (October 1, 1936), but investigation is being conducted to determine the feasibility of such a device; antime, when multiple, simultaneous shot firing is necessitated by the conditions h available multiple shot-firing device should be selected as will give as low- sion current as possible for firing not to exceed 10 shots at a time, with dura- on of current of the smallest fraction of a second. Under no circumstances shoul power lines be used for igniting shots when men are in the mine.

In section 1 of the decision (12), emphasis is properly placed on a shot-hole ing properly drilled and stemmed with incombustible material, such as clay or ale. This applies to blasting with a permissible device as well as with explo- ve.

The only blasting device so far (October 1, 1936) approved by the Bureau con- ins, in addition to liquefied carbon dioxide, a "heating element" that might, der certain conditions of imperfect stemming or if the shot hole intersects a evice or joint plane in coal or rock, produce sufficient external heat to ignite al dust or inflammable gas. In fact, engineers of the Bureau have observed in rtain instances an "illumination" from shots made with this blasting device. reover, the sudden release of high-pressure gas, whether it be carbon dioxide or her gas (or air recently tried in blasting devices as yet not tested by the reau) might, under exceptional conditions, produce sufficient heat by adiabatic

---

2/ Various conditions are considered by Bureau of Mines TP 567 (1936), Preventing Accidents by the Proper Use of Permissible Explosives, by Harrington and Howell.

compression at some point in or adjacent to the shot hole to ignite a methane-air mixture. Hence, the need of incombustible stemming for either blasting devices or explosives.

"Properly stemmed" means tightly tamped stemming. The necessity for proper stemming of explosives is realized, but it has not always been understood to apply to blasting devices. Tight stemming is necessary, not only to prevent possible issuance of flame but also to prevent violent ejection of the shells of the blasting device from the hole. A number of accidents have occurred in which men have been killed or severely injured by violent projection of the shell. In certain instances the shell has rebounded from a corner into a crosscut and caused accidents to workers. In one instance, in an English mine, the shell was shot through the end of a steel mine car. Even if the stemming is tamped tightly men should retire to a safe distance and out of the line of fire or rebound, to an adjacent working place. In Great Britain, a post, sprag, or other suitable obstruction set up in front of the blast hole is now required to prevent ejection of the shell in a dangerous manner. Such a method or an efficient shell anchorage within the hole seems advisable in addition to stemming.

Section 5 of decision 12 recommends that the men who fire the shots shall be certified men and that they shall know what each hole contains before firing it, either by charging it themselves or having it charged under their immediate supervision. It also recommends, as an additional precaution, where the organization of the mine and other conditions permit, that shot firing with explosives shall be done when all men other than those authorized to fire shot are out of the mine.

An alternate safe method is to fire electrically and simultaneously from the surface, all shots in the mine, when everyone has left the mine. (See note (b) of this decision.) This method has been practiced successfully in coal mines of Utah for many years, and also in coal mines subject to instantaneous outbursts of carbon dioxide in the Gard Basin of France.

Decision 13,[23] electrical equipment that should be used in coal mines which may become gassy

The United States Bureau of Mines recommends that when electricity is used in coal mines rated as gassy,[a] or whenever in any mine the atmosphere may become gassy

1. Electrical equipment shall be permissible,[b]

2. Nonpermissible electrical equipment[c] shall be used only in pure intake air,[d]

3. Electrical power shall be cut off whenever the air in the workings is in a dangerous condition[e] due to inflammable gas.

---

[a] Decision 3 classifies coal mines on the basis of the specific amounts of methane found in the mine atmosphere. See, also, decision 9.

[b] Anything that has successfully passed scheduled tests and is officially approved by the U. S. Bureau of Mines is termed "permissible."

[c] Including trolley wires, trailing cable connections other than through permissible junction boxes; and power lines (except armored rubber-covered cables which meet the specifications of the National Electrical Code).

---

[23] Approved Feb. 8, 1930.

d/ Decision 8 defines "pure intake air."

e/ Decision 9 defines the proportion or amount of gas in a mine working which shall be considered dangerous.

The alarmingly frequent explosions of gas and coal dust, due to electrical nition by arcs from trolley wires and bare power lines, that have occurred in al mines in recent years make it highly important that electrical equipment ould be "permissible" when used in any parts of a mine where gas is likely to encountered. The Bureau, in its Mine Safety Decision 3, states that in its inion "all coal mines are potentially gassy," but for purposes of administration respect to the prevention of explosions and fires, it recommends their classi- cation as "nongassy", "slightly gassy", and "gassy."

Decision 9 states that if more than 1 1/2 percent of inflammable gas is found the air of a place, it is in a hazardous condition; and if more than 2 1/2 per- nt is found, no men should remain in the place except those who are charged with e duty of improving the ventilation and are properly protected, as by wearing ermissible" oxygen breathing apparatus and using "permissible" gas indicators at are dependable and accurate.

If the gas inflow into a coal mine from the surrounding strata were constant d the workings and other conditions were uniform, provisions for proper ventila- ion could easily be made, except under abnormally gassy conditions, that would irtually insure against ever having a hazardous gas condition in that mine, un- ess by breakdown of ventilating equipment. But none of the factors are constant; e gas inflow changes as the mine faces advance, new fissures carrying gas are en- ountered, large roof-falls occur that tap gas "feeders" or force out gas collected n caved ground, and the mine workings are constantly changing in shape and condi- ions, all of which, in turn, affect the ventilating arrangements.

It is, therefore, the opinion of the Bureau that the maximum degree of safety rom electrical ignition of firedamp can be obtained by using only "permissible" lectrical machinery and other "permissible" electrical equipment, including loco- otives, such as "permissible" storage-battery locomotives. The Mine Safety Board ecognizes, however, the commercial difficulties of putting the latter recommenda- ion into effect, as, for example, in the haulage system of nongassy mines and in he intake air of mines rated as gassy. Nevertheless, the Board is emphatically f the opinion that nonpermissible electrical equipment should not be used except here the atmosphere is as free from inflammable gas as is specified for "pure in- ake air" in decision 8, which calls for not over 0.05 percent of inflammable gas n "pure intake air." This view is also indicated in Decision 11, "that in coal ining, haulage and (or) hoisting be kept in intake air as far as possible."

Power cables for underground use in coal mines classed as gassy have not as et been covered by a Bureau of Mines schedule of tests for "permissibility." It s tentatively recommended that only those cables termed "armored cables," constructed in accordance with the specifications of the National Electrical Code, be sed, and that the armor shall be electrically continuous throughout and grounded Tech. Paper 402, p. 5).[24]

Trailing cables also have not been covered by the Bureau of Mines schedule or "permissibility". Until a "permissible" list for trailing cables is established by the Bureau, the users of "permissible" machinery should employ the trailing cables recommended for the specific "permissible" machinery. (Details of the general character, installation, protection, and inspection are given in Technical Paper 402.) In all places where inflammable gas might be encountered and "permissible" machinery and armored cable are used, the Bureau recommends that trailing cables should receive current through "permissible" junction boxes.

---

[24] U. S. Bureau of Mines, Safety Rules for Installing and Using Electrical Equipment in Coal Mines: Tech. Paper 402, 1926, 21 pp. (Sponsored by the U. S. Bureau of Mines and the American Mining Congress.)

In gassy and slightly gassy mines there are great hazards in having trolley wires or unarmored power lines extend beyond any open crosscuts. Such electric wires should not extend into rooms, longwall faces, or pillar workings, or beyond any continuously operated ventilating circuit that is not controlled by effective ventilating doors or stoppings. Curtains and loose gob stoppings or any stoppings or doors that allow air leakage should not be considered effective.

One of the greatest electrical hazards, especially in coal mines, is found where auxiliary or booster fans or pumps with nonpermissible motors and connections and bare cables are used in workings, either active or inactive, and especially where the underground fan or pump has an automatic restarting device controlled from a distant switch. The pumps often are used intermittently and inspected only occasionally. Numerous disastrous explosions and fires have been caused by such pump installations. The hazard exists whether the pumps or the fans are in return air or normally on intake air, as falls of roof may bring down gas or an open door may cause gas to accumulate. Where bare power lines are used instead of armored cables explosions or fires may be started by an electric short circuit in a line thrown down by a fall.

Decision 14,[25] clearance spaces for travel in haulageways, shelter holes, and location of trolley and other electrical conductors

In the interest of safety in coal mining,[a] the United States Bureau of Mines recommends:

1. That in all haulageways there shall be a continuous space for travel on at least one side of the trackway, with a clearance of 30 or more inches from the nearest obstruction to the farthest projection of any moving equipment.

2. That any electric conductors other than armored cables, telephone, and low-voltage signal wires shall be placed on the opposite side of the haulageway from the traveling space.

3. That in all haulageways there shall be holes that may be used for shelter, suitably marked, unobstructed, and not over 60 feet apart on the traveling side, not less than 3 feet deep, 5 feet wide, and 6 feet in height or as high as the traveling space if that is less than 6 feet in height.

4. That at sidings of haulageways the tracks shall be so placed that there will be a space between them free from obstruction, at least 3 feet wide between the farthest projections of equipment moving or standing on the two tracks, and where necessary, because of conditions of roof support, this space may be regarded as a substitute for the traveling space, as provided in the preceding sections.

---

[25] Approved Apr. 21, 1930.

5. The provision of traveling space shall be as in (1) wherever practicable; otherwise, the speed of haulage shall be limited to 3 miles per hour.

---

a/ The provisions in the above decisions are in general also applicable and advisable in metal and nonmetal mines.

Accidents in haulageways due to switching, spragging, or coupling, falling from rips, being run over, being caught between car and rib or between car and roof, or it by runaway cars, cause over one-sixth of the total number of accidental deaths n coal mines and a correspondingly large proportion of total injuries. The group f haulage accidents is larger in the aggregate than any group of accidents other han those caused by falls of roof and coal.

State coal-mining regulations usually require shelter holes on main haulageways o be made at intervals of 60 to 100 feet, but none of the State regulations speci- y the minimum width of clearance space between the trackway and the rib or the oarest obstruction. Also, many of the State laws do not specify where trolley or ower lines should be placed in the haulageway; the Bureau makes the definite recom- endation (section 2) that they should be placed on the opposite side of the haul- geway from the traveling space.

Decision 15,[26] wetting machine cuttings, the face, and tops of cars to allay cost dust

In the interest of safety in coal mining, the United States Bureau of Mines to lessen the coal-dust explosion hazard recommends that:

1. Machine coal cuttings be wetted as the cutting is being done.

2. The coal face, and the working place 40 feet therefrom, shall be kept free of coal dust by the use of water.

3. The tops of loaded cars in the working place shall be wetted.

Coal dust is inevitably produced in the cutting, blasting, and loading of coal. The above recommendations are aimed at wetting, as much as possible, the dust at the point of its formation in the working places and thus prevent it from rising, as dry dust will, into the air and being carried and spread widely by the air current. Except for a slight overlapping of the methods to be used at or near the faces of the mine, this decision is not in conflict with decision 5, which recommends rock dusting of all coal mines in every part. In fact, it renders that ecommendation less difficult to be carried out because if a smaller amount of coal ust is distributed around the mine, less rock dust is required for coal-dust eutralization.

Recommendations 2 and 3, advocating wetting the coal face and tops of loaded cars, can best be effected by having water lines extend to each face and watering by hose, each face region being kept supplied with suitable hose. It is hoped that those wetting solutions that recent tests have indicated to be more effective in the wetting of dust than water, and hence require less quantity of liquid, may be obtained commercially at a cost that permits substitution for water.

These recommendations do not apply to anthracite dust insofar as its explosion hazard is concerned, because testing has indicated it will not propagate an explosion. However, it was found to be harmful to breathe by the Public Health Service (Public Health Bull. 221, December 1935); also siliceous dust is frequently associated with the anthracite dust, hence the recommended dust-allaying measures will be beneficial in decreasing the amount of dust harmful to breathe in the air of anthracite mine workings, especially in headways driven partly or wholly in m

---

[26] Approved July 23, 1930.

Moreover, dust in the air, of whatever kind, materially decreases visibility and this increases the hazard to the mine workers through not seeing a threatening fall of roof or coal, or in the handling of machinery, or in haulage and other hazards in the working place, which lead to so many individual accidents in mines, especially in steeply dipping workings.

Decision 16,[27] machine cuttings to be removed in coal mining

In the interest of safety in coal mining, the United States Bureau of Mines recommends that:

1. Machine cuttings be removed from the cut.

2. If the machine cuttings are of a character which would contribute to a dust explosion, they shall be sent out of the mine.

The purpose of having cuttings removed from the machine cut is primarily to prevent coal dust from being blown around the working place in the blasting of coal and, secondarily, to make the blasting more effective and also to avoid the possibility of causing shots to blow out through support of the undercut coal by the cuttings. The cuttings can be removed without unduly stirring dust into the air if the provision of decision 15 of wetting the cuttings before removal is followed.

Recommendation 2 applies to bituminous and subbituminous mines.

Decision 17,[28] lessening the formation and distribution of coal dust in haulageways of coal mines

To lessen the formation and distribution of coal dust in haulageways, the United States Bureau of Mines recommends that in bituminous and subbituminous coal mines:

1. The mine cars should be constructed and maintained dust-tight.

2. The coal should be so loaded that it will not shake off in haulage.

3. The cars and loads should be so sprayed as to prevent dust being distributed along the haulageways.

The recommendations in this decision support those in the preceding decisions 15 and 16. Although considerable dry coal dust is always found at the working face even after watering, it is the falling of the coal from cars in haulage and the blowing of dust from the tops of loads by the air currents that are largely responsible for the wide distribution of coal dust and extensive dust explosions.

Recommendation 1, calling for tight cars, is aimed at preventing the leakage of coal and coal dust along the roadways through cracks in car bodies and around loose-fitting gates. A large proportion of pit cars in the past, as well as at present, permit considerable leakage of coal along haulageways.

Recommendation 2 calls attention to a generally prevalent practice of loading cars high above their top rail, so that when the inevitable bumping in haulage ccurs, the coal is spilled off or the topped coal hits crossbars or a low place n the roof and gets knocked off. Much of this loose coal is ultimately ground to ust under the wheels of the cars and by travel of men.

---

[27] Approved July 23, 1930.
[28] Approved Dec. 20, 1930.

The high topping of cars usually is an indication of insufficient car equipent or of inadequate facilities for haulage from the working places. Any advanage of increased output from the individual working places by topping is probably mporary and is outweighed by having dirty roadways, hence a liability to haulage ccidents and consequent delays and other costs and an increase of the dust hazard.

Recommendation 3 is aimed at preventing dry coal dust on the tops of loaded ars and in empty cars from being blown off by the ventilating current, which is ccentuated by the "wind" produced in high-speed haulage.

A recommendation in decision 15 requires that the tops of loaded cars in the orking place be wetted; recommendation 3 in this decision (no. 17) calls for auomatic spraying of the cars. This is accomplished best by overhead sprays, which utomatically operate as a car is hauled into a gathering siding.

Decision 18.[29] superintendents and foremen of coal mines should have State certificates of competency

In the interest of safety in coal mining, the United States Bureau of Mines recommends that:

1. The foreman regularly in charge of underground operations and also any person who, in the absence of the foreman, may be placed in temporary charge should each have a certificate of competency from the State to act as mine foreman.

2. The superintendent or person in responsible charge of the mine, to whom the mine foreman reports, should have a certificate of competency from the State, which should be issued upon a showing of underground experience for a period of time as long as that required for a foreman's certificate and upon passing an examination including all technical questions asked for in the examination required of foremen.[a]

3. These certificates should expire after some stated period of time, such as 5 years, and should be renewed only after the applicant has again passed the examination required by the State.

---

[a] Requirements for foremen's certificates will cover this provision.

Experience has shown that while foremen, or mine managers as they are termed n some States, must have State certificates, it is not always required that those ho substitute or are in temporary charge have certificates of competency. This is articularly true of the position of mine superintendent, which in many instances s filled by a person who is not a mining man and yet is in real charge of the afety of the employees of the mine and therefore should be competent to direct afely and efficiently when emergencies arise, such as when, by reason of fires or xplosions, the mine foreman may be killed or incapacitated or be made unavailable. urther, where there is no superintendet or responsible top foreman at a mine, but nly a mine foreman or underground manager and perhaps no other employee with a oreman's certificate, the foreman may spend too large a proportion of his time on he surface when he should be underground directing his working shift. Mining laws in a few of the States that have comparatively small mining industries do not require certification of fire bosses, foremen, or superintendents; therefore, in States there is no one at a mine officially responsible for its management, which, manifestly, is not a desirable condition so far as safeguarding the lives of mine workers is concerned.

---

[29] Approved Jan. 18, 1932.

Decision 19,[30] internal-combustion engines for mine haulage

In the interest of safety, the United States Bureau of Mines recommends that:

1. Internal-combustion engines should not be used in any parts of mines and also should not be used in tunnels under construction because of the hazard of carbon monoxide in the exhaust gases, except -

(a) When the air current is more than 100 linear feet per minute and the toxic gases are always less than 0.02 percent in the air current.

(b) When the percentage of inflammable gas in the air current is less than 0.25 percent and (or) inflammable gas cannot be detected in any place by a permissible flame safety lamp.

2. Gasoline or other highly inflammable liquids should not be used for engine fuel in mines and in tunnels under construction because of the hazard of their transportation and use.

Many serious accidents have occurred in mines and tunnels through the use of gasoline locomotives, pumps, and underground hoists. In some instances these have been caused by explosion of the gasoline, either in filling the tanks of the engine or in transporting the gasoline underground. A few years ago a disastrous explosion occurred in a mine in Lorraine, France, when a barrel of benzine (gasoline) fell while being lowered in an upcast shaft, the vapor ignited in some unreported way and the resulting explosion not only wrecked the surface plant but caused fires underground.

In the past there have been explosions and fires and cases of suffocation from exhaust fumes of gasoline locomotives, pumps, and engines in mines and tunnels in the United States, so that many State laws or mining-department regulations have forbidden the use of gasoline engines in mines. State mining laws of most states do not embrace safety regulations for tunnel construction. In driving tunnels for water supply or for general mining purposes in several of the Western States, gasoline locomotives or trucks sometimes have been used, the exhaust gases of which have caused illness and asphyxiation of tunnel workers.

It has been supposed by many that there was little hazard in the use of gasoline locomotives or trucks in tunnels of large cross-section; but in some instances there is a small advance heading in which the gasoline locomotives have been used. In other instances the construction of the permanent tunnel lining at a greater or less distance from the face requires extensive forms and staging, usually built of wood, which restricts the ventilation and thus may bring about a dangerous concentration of inflammable or toxic gases. For example, a gasoline engine might produce locally a physiologically dangerous amount of toxic gases. Furthermore if the strata give off methane, as coal strata ordinarily do, and as sometimes occurs with rock strata, as found in tunneling in places in the Coast Range Mountains of the Pacific coast, an explosive mixture of methane might collect and might be

---

[30] Approved Jan. 20, 1932.

Digitized by Google Original from THE OHIO STATE UNIVERSITY

ited by sparks from the exhaust of the gasoline engine - hence the specifica- ons in the decision requiring a positive adequate ventilating current in which percentage of toxic gases or of inflammable gas shall never be more than the spective percentages specified.

Diesel mine locomotives

Although in mine and tunnel haulage it is safer to employ "permissible" stor- -battery locomotives, if the ventilation requirements are met and other precau- ons are taken it appears from recent European experience, to be safe to employ ap- oved types of Diesel locomotives that use a heavy nonvolatile fuel oil, give off ctically no carbon monoxide in their exhaust, and have spark- and flame-arrest- devices both in their air intake and their exhaust systems.[31] Such locomotives e been approved by the German, French, and Belgian official stations for use in ssy mines. None, however, have as yet (October 1, 1936) been submitted to the S. Bureau of Mines for testing for permissibility, and none have been used in erground mines in the United States so far as known.

This decision does not refer to the use of steam-operated locomotives in mines l tunnels. Formerly such equipment was used extensively in mines in thick coal ds in the Pocahontas region of Virginia and West Virginia and also in tunnels at were being driven in different parts of the country; but so many accidents oc- rred from asphyxiation, that steam-driven locomotives have not been used for many ars except in a few isolated localities. An accident in which several men were lled by suffocation occurred recently in a mine tunnel in which a steam locomotive s used. Even though supposedly adequate ventilation for the tunneling operation ght be provided, the steam locomotive would still present the hazard of causing res by sparks or the dropping of hot ashes and hence should not be permitted in nes and tunnels.

Decision 20,[32] ventilation in the development and operation of tunnels, drifts, slopes, and shafts

In the interest of safety in underground mining, the United States Bureau of Mines recommends that:

While driving tunnels or drifts and sinking or raising shafts or slopes, and also in their operation, there should be an adequate ventilating current[a] wherever men work or travel.

---

[a] For definition of an "adequate ventilating current" see Mine Safety Board recommendatory decision 9.

Before starting a mining or tunneling development, plans and arrangements ould be made for immediate installation of an adequate mechanical ventilation. lthough, under favorable conditions, tunnels or drifts have been driven and shafts r slopes have been sunk many hundred feet while dependence was put in natural entilation, in many instances the absence of mechanically produced ventilation as led to serious accidents and health hazards. These have been due to inflam- able, toxic, or unbreathable gas issuing from the strata, to deficiency of oxygen, nd most frequently to toxic gases from blasting or to the air-borne dust "made" y almost all types of mining processes. Various natural and mining conditions

---

[1] Rice, George S., and Harris, F. E., Diesel Mine Locomotives - Development and Use in European Coal Mines; Rept. of Investigations 3320, Bureau of Mines, November 1936, 52 pp.

[2] Approved Sept. 8, 1932.

make it unsafe to drive a heading or sink a shaft even a short distance without a positive ventilating current produced by mechanical means.

Therefore, whether or not hazards are apparent when an underground development is begun, adequate ventilating plans should be made and mechanical ventilating apparatus installed before starting. For small shallow shafts or short slopes, steam or compressed-air jets placed in upcast ducts may be sufficient, but in all large undertakings a reversible centrifugal fan of ample capacity should be installed with a good-sized air pipe or duct or compartment for the intake or return. In the more difficult developments, as in long, single tunnels making much gas, the use of double ducts for intake and return may be advisable, or at the very least the use of a pipe or tube of sufficient cross section to carry an ample air current not only to supply the human requirements of sufficient oxygen but also to sweep away toxic and inflammable gases produced in blasting or that come from the strata penetrated.

The dangers of insufficient ventilation in coal-mine developments, from accumulated gases and explosions thereof, are understood by experienced mining men, but the danger of encountering inflammable and toxic gases or producing harmful dusts in tunnels driven through rock or unconsolidated material for water supply, mine drainage, or other purposes is too often not provided for. Numerous accidents, however, have demonstrated beyond question that gases in explosive or dangerous toxic proportions are liable to be found in rock strata.[33] Also, there have been many instances of encountering inflammable and toxic gases in reopening old mines and in sinking shafts through sands, gravels, or silt as well as through rock formations of different kinds.

Decision 21,[34] method of setting posts in main haulageways, slopes, and inclined shafts

> In the interest of safety in underground mining, the United States Bureau of Mines recommends that:
>
> In slopes or inclined shafts which are so steep that fallen material may roll or slide, and in main haulageways, posts supporting the roof or sides should be set in protecting niches in the wall. Where this is not practicable, substantial guard rails should be placed along the posts.

As stated in the decision, in slopes or inclined shafts that are so steep that the fallen material may roll or slide, whether these be haulage slopes or inclined shafts, posts supporting the roof or sides should be set in protecting niches or else placed on substantial side walls, so that if a fall of roof occurs the rocks displaced will not, in rolling or sliding, dislodge the legs of timber sets that support the roof, which might bring down other falls. Extensive falls have been caused thus, and in some cases men have been killed or entrapped in lower workings.

Mine cars are likely to be derailed in any mine. Some derailments may be classed as unavoidable because they were due to the falling of rock or breaking of a rail, car wheel, or other mechanical part; weaknesses of this kind often have not been disclosed by customary inspection. But whether avoidable or unavoidable, serious accidents may often be prevented if posts directly supporting the roof and

---

[33] Harrington, D., and Denny, E. H., Gases that Occur in Metal Mines: Bull. 347, Bureau of Mines, 1931, 21 pp.

[34] Approved Sept. 8, 1932.

) sides and the legs of framed sets are so placed or recessed in protective
hes in the sides of the haulageway that they will not be knocked out by derail-
t. This may not always be feasible in temporary haulageways but wherever prac-
able should be done in main haulageways, whether level or inclined; where not
cticable to make recesses, as in hard rock, guard rails or continuous heavy
nks should be placed along the posts and fastened securely to them in such man-
that derailed cars will be fended off and not be likely to pull out the posts
the legs of timber sets.

Decision 22,35/ sealing or guarding surface openings of mines

In the interest of safety in underground mining the United States Bureau of Mines recommends that:

1. All surface openings to underground workings not necessary for the operation of the mine or for escape, which are not adequately ventilated, timbered, and regularly inspected, should be kept securely closed to prevent unauthorized persons entering and surface fires from extending underground; and

2. All openings necessary for operation or escape should be guarded against the unauthorized entrance of persons.

Hundreds of lives have been lost and many million dollars worth of property
been destroyed through neglect to seal the surface openings of abandoned mine
kings. Many of these accidents have been due to men entering unventilated work-
s to inspect without proper safeguards, others to trespassers entering to dig coal
other mineral who are suffocated because of the deficiency of oxygen in the at-
phere of the mine, or poisoned by breathing air containing toxic gases such as
rogen sulphide or carbon monoxide where generated by a smoldering fire in the
e. Many children as well as men have entered abandoned workings or old shafts
a spirit of curiosity and have been asphyxiated or killed or injured by falls of
of or by their falling down a shaft.

The greatest loss of mining property and mineral reserves that occurs when
rface openings are left unsealed, is due to fire. In many instances a small neg-
cted fire has spread through great areas of workings. One extensive fire in an
d anthracite mine working is said to have started from dumping hot ashes into a
le at the outcrop. This fire spread through several hundred acres of old pillar
rkings, caused many houses on the surface above to be abandoned because of gases
d fumes rising through cracks, and was not stopped until it reached a solid coal
rrier which was deep enough below the surface and which dammed back water entering
om a higher point.

Wherever beds of coal outcrop above the ground-water level of the particular
cality and there are unsealed openings, fires are liable to occur. Among the
re general causes are spontaneous combustion in slack piles especially those of
bbituminous coal and from other surface fires that extend into the mine openings
set other coal outcrop on fire. In some instances these surface fires have been
arted carelessly by persons igniting brush or building a small fire in or near
e mine opening for heating, and doubtless in other cases the fires have been
arted maliciously. However, there have been many instances in which lightning
nited brush or timber, from which a fire might spread into a mine or ignite a
al outcrop.

/ Approved Sept. 8, 1932.

It is evident that the cost of sealing abandoned workings is insignificant when compared with the property damage that may result from fires - apart from th human toll already mentioned.

The question arises as to the responsibility for such occurrences. If a mi of any size is to be abandoned, it is usual to take out the machinery and underground tracks. After that is accomplished, the surface openings should be sealed by erecting strong brick or stone walls properly plastered or possibly solid concrete stoppings. Where it is thought that the mine might be reopened, steel or concrete doors should be erected and effectively padlocked. In all cases, the doors and frames should be of incombustible material.

When it is definitely known that a mine is to be abandoned, before the seals are erected it is advisable that the roof of drifts and slopes be blasted down fo some distance inside their entranceway. In the case of shaft openings, if shallo they should be filled; if deep, a thick reinforced concrete slab can be built across the shaft, extending into the shaft walls for its support. If this is not feasible, strong high wall enclosures should be built on the surface around the shaft opening.

Sealing of old workings to prevent mine waters becoming acid

There is another important advantage in sealing drift or slope openings into old mine workings in which the waters are acidic and from which water accumulates and overflows. It has been found by investigations of the Bureau of Mines that acidity of the mine water is largely stopped by excluding the air from the mine and thus preventing oxidation of pyrite, which is practically always found in coal strata. After the mine has been sealed, the entrance of normal subsurface waters, which are alkaline, will flush out and (or) neutralize the acid salts already for The present condition of acid water running out of old coal-mine drifts in some parts of the country has presented serious problems of stream and river pollution, notably in Pennsylvania and West Virginia. In some instances the mine owners have been legally compelled to go to heavy expense for construction of diversion dams and tunnels.[36] Hence, the sealing of unused mine workings where it lessens the acidity of waters flowing from the mine has advantages beside those of safety and prevention of fire loss.

Concerning the second clause of the above decision, which recommends "all openings necessary for operation or escape should be guarded against the unauthorized entrance of persons," it is obvious that where the openings are main shafts or slopes, they will or should be guarded by officially designated employees; but at many extensive mines escapeways or air shafts are situated at long distances from the main openings. Such distant openings should be guarded by iron doors or substantial iron-barred gates. These should be self-closing and provided with snap locks that can be opened quickly from the inside to permit escape or normal exit but that require a key for unlocking from the outside. The key or keys for such purpose should be in the possession of authorized persons only.

Decision 23,[37] checking men into and out of mines

In the interest of safety in underground mining, the United States Bureau of Mines recommends that:

---

[36] Leitch, R. D., A General Review of the United States Bureau of Mines Stream-Pollution Investigations: Rept. of Investigations 3098, 1931, 7 pp.

[37] Approved Sept. 8, 1932.

Every underground mine should keep a record in a safe and quickly accessible place on the surface, which will show the time when each person goes into and when he comes out of the mine, and which will also show, insofar as practicable, where he may be found while in the mine.

The experience of well-organized mining companies has been that it is an eco- ic as well as a safety measure to make a record on a suitable form of the time n each man enters the mine. It is advisable that this record include the prob- e place or places where the man will be working during his shift; but there might exceptions to this in the case of foremen or inspectors or other workers who may called upon to visit various parts of the mine. There should also be made on record entry of time when each man comes out of the mine.

One method of keeping such records is to have them made by a clerk in or ad- ent to the lamp room where safety lamps or electric lamps are issued. At some es a man receiving a lamp is given a numbered metal check, the duplicate to which hung on the check board at the same time. When the man comes out of the mine he renders his lamp and check and the time is noted, or should be, on the record.

At other mines, punch-clocks are employed to register the time when a man en- 's and when he leaves the mine. Also, at some mines, push-pins with numbered ds corresponding to the men's check numbers are pinned on wall maps of the mine the position of the respective working place.

Where such records are kept, if a man should not come out of the mine at the of his shift the unclaimed check would give warning of a possible accident to and a search for him would be made promptly. If the mine were so unfortunate to experience an explosion or fire, an inspection of the record would give know- ge as to those who might be in the mine and where they most likely could be lo- ed by the rescue crews. In some cases, the checking system has been made inef- tive because the check board containing the record was so located that it was troyed by the force of an explosion in or issuing from the mine, or because the ord (check board) was cut off from access through being located in mine workings led with smoke and fire gases at time of mine fire. For these as well as other sons it is desirable that the record be kept in a safe as well as a convenient ce on the surface.

Decision 24,[38] guarding trolley and bare power lines

In the interest of safety in underground mining, the United States Bureau of Mines recommends that:

1. Trolley and other bare wires should be adequately guarded wherever the wire is less than 6 1/2 feet above the level of the top of the rail;

2. In mines using loading chutes on one side of the haulage-way, the trolley and other bare power wires should be placed on the opposite side and adequately guarded at the chute.

3. Trolley and other bare power lines should be sectionalized by electrical switches which can be safely handled, at the entrance to different parts of the mine; and

---

/ Approved Apr. 11, 1933.

4. Trolley and other bare power lines should be adequately supported by strong, insulated hangers so spaced that if a hanger is missing the wires will not sag or shift and thus constitute a hazard.

Shocks and fatalities from electric power lines in mines have been one of major classes of accidents in both metal and coal mines, especially in recent most of these accidents are due to men coming in contact with trolley lines and power lines on haulageways. Although it is advisable that separate passageways manways for the travel of the majority of the employees be provided in which bar power lines are safeguarded so as to reduce the exposure of most of the employees to electric shocks, it is difficult to provide separate manways in all parts of mine; hence, the advisability of following the specifications for installation of trolley and bare power lines in the above decision. It is important that where have to travel in trolley haulage entries in coal mines or levels in metal mines that the trolley wire not be carried on the side of the roadway where the men tra as stated in decision 14.

Many mining men seem to consider that guarding bare power wires, including trolley wire, at the main intersections or similar places where men pass under is sufficient protection; but there have been hundreds of fatal contacts with unguarded bare power wires at other points where men moving or coupling cars or re-railing them, or the motorman or his helper for some reason or other, have come contact with the bare unguarded power wire. Power lines should always have well grounded armored covering and in long-lived entries or levels should be placed in recesses in the rib or in conduits buried below the floor level.

Numerous metal mines and many coal mines have installed and maintained contin-ous guards for trolley wires, consisting of side boards or split rubber hose, throughout the trolley haulage roads and have been amply repaid by the resultant freedom from accidents caused by contact with the trolley wires.

Decision 25,[39] barrier pillars between adjacent mines

In the interest of safety in underground mining, the United States Bureau of Mines recommends:

1. That every mine contiguous to one or more mines in the same vein or bed should, so far as practicable, have separate ventilation, haulage, and escapeway systems, and the underground workings of each mine should be separated by a strong barrier pillar to prevent a fire or an explosion penetrating from one mine to another. Provision should be made to relieve excessive pressure of accumulated water on one side of the barrier.

2. In case mines already are connected and thereafter it is practicable to provide satisfactory separate ventilation, haulage, and (or) escapeway arrangements for each mine, a barrier pillar should be established and the openings which connect the mines should be sealed by strong, tight, fireproof stoppings or pack walls.

3. The barrier pillar should be maintained intact until the workable mineral has been completely removed from the contiguous workings; then, if permitted by the respective State requirements and property restriction, and if it can be done with safety, marketable mineral in the barrier should be extracted.

---

[39] Approved Feb. 3, 1933.

Many fires in metal mines or the gases and smoke from the fires have passed
one mine to an adjacent mine with disastrous results to life and property. In
mines similar serious results have occurred from mine fires and explosions,
latter sometimes causing even more disastrous results to life than do fires.
e results have occurred either because of the absence of barrier pillars or be-
e the connecting headings or openings were unguarded by fire- and explosion-
sting stoppings and doors.

Under authority of an act of Congress, approved February 25, 1920, operating
lations to govern coal-mining methods and the safety and welfare of miners on
ed lands on the public domain were formulated by the Bureau of Mines and approved
he Secretary of the Interior, April 30, 1921. Sections 104a and 104b, which in-
e essentially the recommendations in decision 25, also call for a lateral
ngth of stoppings to resist mine explosions having a pressure of at least 50
ds per square inch on either side of the stoppings. Results of the tests made
he Bureau of Mines in conjunction with the Bureau of Standards and recommenda-
s made for the construction of stoppings were published in Bureau of Mines Bul-
in 345, referred to previously (footnote 15, p. 13.).

Justifiable exception may be made to recommendations of sealing all connections
ugh a barrier pillar to an adjoining mine when, under conditions that are liable
arise, there is need of maintaining an escapeway through the barrier pillar and
oining mine, provided, however, that adequate ventilation and timbering is main-
ned in the escape passages on each side of the barrier and also provided that
el or reinforced-concrete fire doors in sets of two or three are installed in
stantial frames of steel and concrete. Additionally, in bituminous-coal mines,
roved "rock-dust barriers"[40] for extinguishment of coal-dust explosions should
maintained in the escape passages on each side of the barrier pillar.

As regards removal of barrier pillars where there is not danger to property
lives, a Pennsylvania legislative act (1929) permits removal when approved by a
cial commission for each specific case.

Decision 26,[41] allaying dusts harmful to breathe in the air of mines and tunnels

In the interest of health in mining and tunneling wherever dust is produced which is of such character[a] and in such concentration[b] in the air of the working places as may be harmful to breathe, the United States Bureau of Mines recommends:

That the dust produced be so wetted,[c] trapped,[d] or otherwise treated,[e] and the place where men are working be so ventilated,[f] that there shall not be a harmful concentration in the air of the place.

---

[a] Character of dust refers to size and composition, such as siliceous dusts and other dusts poisonous in effect.

[b] Concentration of dust in air refers to amounts, varying with the character, that will be harmful to breathe. The determination of the amount for each specific dust and the method of sampling are subjects of research by the United States Bureau of Mines in cooperation with the U. S. Public Health Service. Reports and

---

See footnote 13, p. 12.

Approved June 2, 1934.

tentative recommendations on these subjects are issued from time to time by these organizations.

c/ "Wetted" means as may be done by sprays or jets of water or chemical solutions; in drilling, the wetting in the drill hole may be done by water-injection drill or solution-injection drill.

d/ "Trapped", as may be accomplished by suction of the dust-laden air and collecting the dust in an apparatus of one kind or another.

e/ "Treated", as may be done by chemical solutions applied, as stated above, by sprays, jets, or injection drills.

f/ "So ventilated", means by air currents of sufficient velocity and volume to carry away from any working place harmful dust not caught by wetting or by trapping devices and, wherever possible, discharged into the return airways.

The increasing use of mechanization in mining and tunneling of various kinds, with consequent concentration of work, is causing a greater production of dust in any one working place, which naturally tends, where suitable precautionary measures are not taken, to increase the amount of the dust in the air of the place, and consequent exposure of the workers to breathing larger amounts of it.

This situation has brought about greater health hazards and presents serious economic problems, not only in metal mines but in various kinds of mining operations, including shafting, tunneling, and quarrying, and also in mineral-preparation plants. Apart from the need of humanitarian considerations, the rising burden of personal compensation costs to the respective industry required greater precautionary measures to be taken by it than formerly.

The presence of large amounts of finely divided dust in the air of underground working places greatly reduces visibility, which is in itself a hazard and is another good reason for taking all feasible precautionary measures to hold air dustiness in mining and tunneling to a minimum. This has been previously discussed in connection with wetting coal dust (decision 15, pp. 25, 26).

Scientific physiological research in various countries has determined the deleterious character of some mine dusts of specific fineness and concentration in the air breathed. It has long been known, for example, that pure silica dusts of certain kinds, fineness, and concentration per unit volume of air breathed produce what is commonly known as silicosis or "miners' consumption." But it is now found that some silicate and other mineral dusts also cause pulmonary troubles.

It will require long-time laboratory and field investigations to determine the degree of hazard of each kind of dust produced in mining and tunneling and to standardize methods of sampling and testing the allowable maximum concentration in air for each specific dust. The application to special cases is complicated by the difficulty of determining the susceptibility of the individual worker and his previous exposure to breathing deleterious dust. A further complication arises because the concentration of dust in the air in any working place changes rapidly and with advance of a mining face or breast in passing through different formations, the character of the rock or ore encountered changes as does the character of the dust of the working place which arises into the air.

Moreover, workers are moved frequently from one working place to another in ine, or the worker may shift to another mine, thus making physiological nosis difficult.

Continued biological and field clinical studies of workers by various organi- ons, and improvement in the technique of methods of sampling and testing the ree of concentration of dust in the air breathed, will doubtless lead to changes he present tentative limits of particle size and allowable concentration in the of dusts now known to be injurious, and also in the precautionary methods to be en. Meantime, however, the protective measures for allaying or lessening the int of dust produced in mining and tunneling, recommended in the foregoing de- ion and in explanatory notes b, c, d, e, and f, of this decision should be fol- ed.

Publications on different phases of the various subjects mentioned in the last agraph are too numerous to cite here; among others, reference should be made to se issued by the U. S. Bureau of Mines and the U. S. Public Health Service.

Decision 27,[42] construction of shaft linings as concerns fireproofing and ventilation

In the interest of safety, the United States Bureau of Mines recommends:

1. That the lining of all mine shafts shall be fireproof.[43]

2. That the lining, so far as feasible, be smooth and without projections or recesses, so as to prevent:
   (a) Turbulence of the ventilating current;
   (b) Accumulation of dust, especially inflammable dust;
   (c) Lodgment of rock or other material.

The Bureau of Mines recommended in section 2, decision 7, "that the main in- ke shaft lining be of fireproof construction and that there be a minimum amount inflammable material in or adjacent to the shaft." This recommendation is not tended to prevent the use of wood guides. Construction of shaft lining with non- mbustible material has been used to a limited extent in the United States but is e general practice in European mines, where most shaft linings are brick or con- ete, or iron tubbing, through water-bearing ground and are circular or elliptical cross section. For a long-lived shaft, such form and noncombustible construc- on is highly desirable because it is strong and permanent and offers the minimum sistance to air flow.

In the United States, however, most shafts are wood-lined and rectangular in ss section and as yet only a small proportion are fireproofed, or of noncom- stible construction, except where fireproofing is required by State mining regu- tions, as in Illinois[44], since the Cherry mine fire disaster, but there is a grow- g feeling among mine operating men that shafts should be fireproofed - particu- rly intake air shafts and shafts used for escape purposes.

As many disastrous fires in both metal and coal mines have occurred in or been nnected with wood-lined shafts, it is evident that in the interest of safety and

---

/ Approved July 13, 1935.

/ Webster's dictionary (1924) defines "Fireproof: proof against fire; relatively incombustible."

/ See "Fire-Fighting Equipment in Coal Mines" (effective July 1, 1910), Illinois General Mining Laws (Sec. 6, a and b).

fire prevention, as well as for permanence, all main-shaft linings should be constructed of incombustible material. If, however, wooden lining is used it should be made fire-resisting, as by covering with cement-sand coating or gunite reinforced with wire mesh.

Most wooden shaft linings are made of frames or horizontal sets of squared timbers placed 3 to 5 feet (vertically) apart, with plank lagging behind the frames in contact with the rock or ground; but when the strata appear solid the lagging sometimes is omitted. In either case the timber sets form deep recesses in the sides of the shaft 6 to 8 inches, or even 12 inches deep in heavy ground, in effect forming wide shelves.

The effect of these recesses is:

1. That much ventilating power is lost through air turbulance where an air current traverses a rough duct, compared with traversing a smooth lined duct.

2. Dust collects in these shaft recesses. The dust in some cases may be highly inflammable, such as coal dust and pyritic dust carried by air currents or otherwise in the shaft. Such dust, when in a dense cloud, has propagated explosions into the mine workings from ignitions by open lights or electric "shorts" or arcs in the surface tipple building.

3. The recesses catch pieces of rock or coal - often of large size - falling from cages or skips or from the surface. These loose pieces subsequently may be dislodged by air currents, by the falling of other pieces, or by some shock, and may fall on persons on hoisting cages or at the shaft landings.

INDEX

ioned and unventilated workings, presence of gas in 8, 12, 31, 34
ity of mine waters, prevention of by sealing 32
nce mining, coal mines, requirements for safety and ultimate
covery 13
mine, in unsealed places, necessity of circulating 8, 10, 14
quality and quantity in ventilating splits 8, 15
maximum number of men on split 17
testing and sampling 6, 8
coursing ventilating currents 18
"pure intake air," definition of 14
doors, stoppings and regulators for ventilation 16, 17
requirement, minimum per man per minute 15
currents, intake and return in separate shafts, slopes, or drifts 13, 30
ducts in tunnels or drift headings 30
ying dusts harmful to breathe in the air of mines and tunnels . 35
iliary fans in coal mines, dangers of using as substitute for
egular coursing of air 10
rier pillars, between adjacent mines, to prevent penetration of
ire and explosions 34
of workable mineral, extraction of when contiguous mineral has
been removed 34
rier-pillar openings, sealing of by strong fireproof stoppings . 34
riers, rock-dust, to secionalize coal mines in dust-explosion
revention 11
ck blasting powder, hazard of using in coal mines 7
ckdamp, detection by flame safety lamps 6
sting appliances, or devices 19, 21
need of incombustible stemming for and retirement of men at
safe distance when firing 21, 22
permissible, employing cylinder containing compressed carbon
dioxide and heating element 20, 21
sting, in coal mines, precautions 6, 19
sting methods by permissible devices 21
sting off the solid, hazard of 7
wer fans, electrically driven, hazards of in coal mines 10
wers, as substitute for regular coursing of air, dangers of ... 10
booster fan 10, 11
wn-out shot, hazards of 20
les, armored rubber-covered 22, 23
trailing, and connections 22
rbon dioxide, compressed or liquefied, in cylinder with heating
element, as a permissible blasting device 20, 21
rs and loads, spraying to prevent distribution of dust along
haulageway 25, 35
rs with cracks or loose-fitting gates cause distribution of coal-
dust along roadways 26
ecking and recording men entering into and coming out of mines .. 32
assification of coal mines according to gassiness 7, 8
earance spaces for travel and haulageways 24
osed-light mine, requirement for permissible miner's lights 5, 6, 9
al, on cars, wetting in working place 25
loading so that it will not shake off in haulage 26

Coal-cutting or shearing, preceding blasting 6,
Coal-dust, allayment of by use of tight cars and water sprays 26,
    anthracite-dust not explosive but harmful to breathe 11,
    distribution of, by leaky cars and high loading 26,
    explosion of, prevention by rock-dusting 11,
    lessening formation and distribution of, by wetting at face and on cars 25,
    wetting solutions for allayment of dust 25,
Coal-mine ventilation, continuous coursing recommended 10, 14,
Coal mines, classification according to gas found therein 7,
    coal-dust explosions, prevention of by rock dusting 11,
    coal mines, damp or dry, necessity of rock dusting ....
    new, gassy or nongassy, precaution in opening ....
Compressed-air driven blowers in coal mines ....
Construction of shaft linings as concerns fireproofing and ventilation ....
Coursing of ventilating currents in mines 13,
Cut-through or crosscut for ventilation ....
Cutting and shearing coal should precede blasting 6,
Cuttings, machine, wetting recommended 25,
Curtains, not considered as tight or safe equivalent of stoppings ..
Decisions, Mine Safety Board, the formulation and initiation of ...
Defining nongassy, slightly gassy and gassy coal mines 7,
Definitions used in mine ventilation regulations ....
"Depending" shot, hazard of ....
Detonator, electrical 7,
Diesel mine locomotives ....
Doors, ventilating ....
Drilling and stemming holes for shot firing 7,
Dust, allaying of harmful dusts in mines and tunnels by wetting, trapping, or by chemical treatment ....
Dust hazards to workers 25,
Dynamite, hazard of using in coal mines ....
Electric detonator 7,
Electric miners' lamps, portable 5,
Electric-shock hazards in mines ....
Electrical armor, rubber-covered cables (meeting specifications of the National Electrical Code) ....
Electrical equipment, limitations in use in gassy or slightly gassy coal mines ....
    nonpermissible, necessity of placing in pure intake air ....
Electrical firing of explosives in coal mines 7, 21,
Electrical junction boxes, permissible ....
Electrical power, cut off in dangerous atmospheres ....
Electrical power lines (nonpermissible except armored rubber-covered) 22,
Electricity in mines, recommended limitations of place of use to lessen hazards ....
Escape from mines, two ways necessary 17,
Escapeways, arrangement and construction of lining 17, 18,
    through connections to adjoining mines, protecting fire doors and, in coal mines, approved rock-dust barriers ....

ane in natural gas 8
ts, safe, provided by fireproof lining of intake shaft 18, 37
'losibility limits of (a) natural gas in air, (b) methane in air. 8, 9
losions, fires, and suffocation, caused by gasoline locomotives, umps, and engines in mines 28
losions, coal-dust, prevention of by rock dusting and limiting f by rock-dust barriers 11, 12
losives, permissible, stemming and firing, single shots 6, 7, 19, 20
  delay action detonators dangerous in coal mining 21
  methods of blasting, multiple shot firing in coal mines 20, 21, 22
losives to be used in coal mining (a) permissible, (b) hazards f others 6, 7, 19, 20
s, surface, increase in power of for adequate ventilation 11
s, underground, auxiliary, dangers of use in coal mines as ubstitute for regular coursing of air 10, 11
  booster, use rarely justified 11
edamp, detection of in mine air 5, 6
edamp or methane, accumulation of, to be removed by ventilation, 15, 16
e hazard and firedamp ignition from open lights 6
eproof lining of main intake shaft, and of other shafts 14, 18, 37
eproof shaft lining 14, 37
eproof stoppings acting as seals should be strong 13
eproofing in vicinity of underground fans 10
es, on surface, likelihood of extending underground through unguarded openings of mines 31, 32
ing shots from surface 22
ing shots in coal mines, methods of 19
me safety lamp, use of, gas detection 5, 6, 8
remen and superintendents of coal mines, holding State certificate of competency, need for 27
s, examination for before blasting 19
  inflammable, dangerous percentage, men withdrawn 15, 16
  inspection for 15, 16
  removal by ventilation 15, 16
s-detecting devices, permissible equivalent 5, 6, 8
s detection, flame safety lamp for 5, 6, 8
seous mines. See gassy mines 7, 8
ses, inflammable and toxic, encountered in rock and coal strata 9, 30
soline or other inflammable liquids should not be used for engine fuel in mines and tunnels 28
ssy conditions, dangerous 15
ssy mines, definition of 7, 8
ard rails, to protecting posts or roof supports in haulageways, slopes, or inclined shafts 30
arding trolley and bare power lines 33
rmful effects of certain dusts 25, 35, 36
ulage, in intake air, recommended 18
  tight mine cars for, proper loading and spraying the coal with water 26
ulageway posts, supporting roof or sides, to be set in niches or protected by guard rails 30
ulageways, lessening formation and distribution of coal dust on 25

Hoisting, in intake air recommended
    neutral shaft for
Hose, for watering face region to allay coal dust
Ignition, of firedamp and coal dust
    (a) by open flame
    (b) by explosive
    (c) by electrical spark
Illumination, good, to lessen general accident hazards
    portable miners' electric lamps recommended for
Inflammable gas, coal mines classified according to percentage found
Inspectors or foremen or fire bosses, State certificates for
Insulation, electrical armored cables
Intake air, haulage and hoisting in
Intake air and return air defined
Intake air current, should be in separate shaft, slope, or drift
Internal-combustion engines, not to be used in mines or tunnels except where adequate ventilation; and highly inflammable liquids (like gasoline) should not be used for fuel
Junction box, permissible electrical
Lamps, miners', in coal mines
Line brattices, recommended in coursing of air to face of workings.
Loading cars above top of rail, spillage of coal and dust caused by
Machine cuttings of explosive character, to be sent out of the mine after wetting
    to be removed from cut before blasting
Machinery, electrical, should be permissible in gassy mines
Mechanization of coal mines, influence of as affecting safety
Members of the Mine Safety Board, past and present
Methane, presence, detection of
Methane in air, percentage found to classify mines, explosibility limits
Methods of firing shots in coal mines
Mine air, testing and sampling
Mine cars, constructed and maintained dust-tight
Mine openings, abandoned, closing securely
Miners' lamps in coal mines
Mine Safety Board, establishment of
    members, past and present
    objective
    procedure
Mine Safety decisions, list of
Multiple shot-firing, conditions requiring exceptions to decision 12
National Electrical Code
Natural gas escaping into mine air, explosibility limits
Nongassy mines, conditions constituting
Nonpermissible electrical equipment, use only in pure intake air
Nonpermissible explosives, hazard of using in coal mines
Open-light mine not synonymous with a nongassy mine
Openings to mines not adequately ventilated, timbered, and inspected to be securely closed to prevent entrance of persons and fire

casts, undercasts 17
cutting, undercutting, or shearing coal prior to blasting 6, 7
en deficiency, detection of in mine air 6
en in mine air, recommended minimum limit 15
missible," definition of 5
issible electric machinery and equipment 19, 22, 23
issible explosives 6, 19
issible miners' lamps 5, 6
sons in charge of a coal mine to have State certificates of
 mpetency 27
lar extraction, complete as possible and withdrawn on long line. 13
ts supporting roof in main haulageway slopes and inclined shafts
 be placed in niches or have guard rails 30
er lines, unapproved, trolley wires, and nonpermissible equip-
 ent in coal mines to be placed in pure intake air only 22, 23
  guarding adequately 33
  insulated, rubber-covered, armored 22-24
  position in and haulageways and entries 24, 33
  sectionalizing by electrical switches 33
  supporting adequately 34
vention of coal-dust explosions by rock dusting 11, 12
ntity and quality of air needed in ventilating of coal mine 15, 16
irculation of air by blower fans, danger of in gassy mines 10, 11
ording the entrance of each man into a mine and time of his
 oming out and where he may be found while underground 32, 33
reating mining, like retreating longwall, avoidance of accumula-
 ion of gas and coal dust 13
urn air current, necessity of providing separate shaft, slope,
 r drift for 13
k dust, early investigations of, for coal-dust explosion pre-
 vention, by Garforth, Rice and associates 11
  use in coal mines, amount and specifications 11, 12
ck-dust barriers, secondary defenses to limit coal-dust explosions 11
ck-dusting coal mines 11, 12
  Great Britain and France, requirements 11
bber-covered, armored cables 22, 23
mpling and analysis of mine air 8
aling or guarding openings to abandoned mines or openings not
 necessary for operation of mine 31, 32
aling with strong fireproof stoppings parts of coal mines that
 cannot be ventilated 12
aling old workings to prevent mine water becoming acid 32
parate shafts, slopes, or drifts for coursing "intake" and "re-
 turn" air currents 13, 14
aft intake, advisability of fireproofing 14, 37
haft lining, construction of, as concerns fire-proofing and
 ventilation 14, 37
haft partition between an intake and return, dangerous in case of
 fire or explosion 13, 14
hearing or cutting coal should precede blasting 6, 7
helter holes in haulageways 24

Shot, blown-out, hazard
  "depending," hazard
Shot firing, electrical, from surface when all men are out of mine, in coal mining
  conditions requiring exceptions to single shot firing
  shots for should be prepared and fired by man having State certificate 19,
Shot-firing blasting units, single (permissible)
  multiple 22,
Slightly gassy coal mines, conditions constituting 7,
Splits, ventilating, maximum number of men advisable on one split and percentage of gas therein for classifying coal mines
State regulations for coal mines with reference to gas classifications
Steam-operated locomotives should not be used in mining
Stemming and drilling hole for shot firing 7,
Stemming for permissible explosive or permissible blasting device to be of incombustible material 19,
Stoppings, for seals, necessity of being fireproof and strong 12,
  gob wall, in rooms
  board, in rooms
  in connections between mines, required by operating regulations to govern coal-mining methods on the public domain, to be of a certain strength
Superintendents and foremen of coal mines to hold State certificates of competency
Supporting post, protection in, main haulageways, inclined slopes and shafts, niches, or guards
"Topping" of coal on cars leads to making of dust 26,
Trailing cable, machine 25,
Trailing-cable connections, junction boxes 22,
Trapping dust harmful to breathe 25, 35,
Travel clearance in haulageways 24,
Trolley wires, hazards of 22, 23, 33,
  power lines, location, supports and guards 33,
Tunnels, drifts, shafts, and slopes in construction and operation adequate ventilating current for 29,
Unauthorized entrance of persons into mines should be guarded against
Undercutting, shearing, or overcutting coal prior to blasting 6,
Ventilating current, percentage of gas therein for classifying coal mines 7,
  gas content, reducing to safe percent before blasting
  in development and operation of tunnels, drifts, slopes, and shafts 29,
  relating to quality and volume circulated 15,
Ventilating doors, stoppings and overcasts 16,
Ventilation, construction of shaft linings for good ventilation 37,
  coal and other mines, recommended quality and quantity 15,
  coal mines, necessity of sealing unventilated parts 12,
  definition and specifications of "pure intake air" in coal mining 14,

Original from THE OHIO STATE UNIVERSITY

ilation, definition of "intake" and "return" used to define
echanical movement and not degree of purity 14
  line brattices, and curtains 10, 16, 17
  number of men, maximum advisable, in one split 17
  oxygen,minimum,and carbon dioxide maximum advisable 15
  planning for and installing apparatus before starting mining
    or tunneling 29
  requirements in places where harmful dusts occur 35, 36
  unit quantity per man per minute and quality of air advisable. 15, 16
  volume of air per man per minute minimum recommended 15, 16
er seal in barrier stoppings to prevent undue pressure 13
er spraying of cars and loads to prevent distribution of dust
long haulageways 26
ering by hose at face 25
ting, allaying of dusts harmful to breathe 35
ting or watering machine cuttings and tops of loaded cars to
llay coal dust at coal face 25
ting solutions for allayment of dust 25, 35
kings, abandoned or unused, need of sealing openings to them
rom surface 12, 13, 31